Mexican Wolf Recovery: Technical Component of the Five-Year Program Review and Assessment

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Note to Reviewers:

The general paper occurs from pages 3 to 42, with tables and figures following the Literature Cited. For a quick overview of the paper and the essential questions of the review please refer to Appendix II on pages 79-81.

Appendix III is suggestions and replies received from the public during the three-year review process.

INTRODUCTION

As with other gray wolf populations, the Mexican wolf (*Canis lupus baileyi*) was persecuted in the wild and eventually was extirpated from the southwest United States in part because of conflicts with livestock (Brown 1983). Many techniques were used to eradicate Mexican wolves including trapping, shooting, and poisoning with strychnine, arsenic, or sodium cyanide (Brown 1983, Parsons 1996). The Predatory Animal and Rodent Control Service was probably most effective at removing wolves from Arizona and New Mexico from 1915 to 1925, when government trappers systematically removed about 900 wolves (Brown 1983). Wolves still inhabited parts of Mexico until the early 1980's, primarily because the efforts to eliminate wolves there was not as effective.

Very little is known about the natural history of the Mexican wolf prior to its reintroduction in 1998 (Parsons 1998). The Mexican wolf is the most genetically distinct (Garcia-Moreno et. al. 1996) and southern most occurring subspecies of gray wolf in North America (Parsons and Nicholopoulos 1995, Nowak 1995). One obvious difference between Mexican wolves and other gray wolves is their size. Historic weights of wild Mexican wolves ranged from 25-49 kg (54-99 lbs) (McBride 1980, Leopold 1959, Young and Goldman 1944). Prior to reintroduction of Mexican wolves, biologists suggested that their primary prey had been white-tailed deer and mule deer (Brown 1983, Parsons 1998); however, initial data collected on Mexican wolves since their reintroduction indicates their current primary prey is elk (Reed 2004).

Historically, Mexican wolves ranged throughout a significant portion of the southwestern United States and northern and central Mexico. This range included eastern and central Arizona, southern New Mexico, and west Texas (Parsons 1996). Wolf extirpation in New Mexico was estimated around 1942 (Bednarz 1988); however less than 50 Mexican wolves still existed in Chihuahua and Durango, Mexico in 1980 (McBride 1980). Surveys in Mexico have not been able to confirm the presence of wolves in the wild (Carrera 1994) and it is very unlikely that a viable population in Mexico currently exists (Parsons 1996).

Five wolves (4 males and 1 pregnant female) were live-trapped in Mexico between 1977 and 1980 to establish a captive population known as the “Certified” lineage (Parsons 1998). Two other lineages, both from captive facilities in the U.S. and Mexico, were certified for the captive breeding population in 1995 (Hedrick et al. 1997). These wolves were classified as the “Aragon” and “ Ghost Ranch” lineages making a total of seven original founders of the Mexican wolf captive breeding population.

The Mexican wolf was listed as endangered under provisions of the Endangered Species Act (ESA) in 1976 (Parsons 1998). The Mexican Wolf Recovery Team was formed in 1979 and the Mexican Wolf Recovery Plan was approved and signed by the U.S. and Mexico in September of 1982 (U.S. Fish and Wildlife Service 1982). The main objective of this Plan is to maintain a captive population and to re-establish a viable, self-sustaining wild population of Mexican wolves. Following an Environmental Impact Statement (EIS), the Secretary of the Interior approved the reintroduction of Mexican wolves to establish a population of at least 100 wolves in the Blue Range Wolf Recovery Area (BRWRA) in March of 1997 (U.S. Fish and Wildlife Service 1998). The U.S. Fish and Wildlife Service (USFWS) classify wolves reestablished in this area as a “nonessential experimental population” under section 10(j) of the ESA (U.S. Fish and Wildlife Service 1998). In 2003, the USFWS reclassified the gray wolf in North America creating three Distinct Population Segments (U.S. Fish and Wildlife Service 2003). Under this reclassification wolves occupying the Southwestern Distinct Population Segment (SWDPS) including the current BRWRA population, was listed as endangered and a recovery team was convened to develop a new recovery plan for the SWDPS, which is expected to be completed in 2006.

In 1998, Mexican wolves were first reintroduced to the BRWRA. Eleven Mexican wolves were released into the primary recovery zone in March of 1998 (Parson 1998). Additional individuals and family groups of Mexican wolves have been released or translocated into various parts of the BRWRA each year through 2003. Interagency Field Team members (IFT) have monitored the reintroduced population for reproduction, prey habits including livestock depredation, and other biological traits of Mexican wolves. Predictions in the EIS indicated that the wolf population at six years would be about 55 wolves (U.S. Fish and Wildlife Service 1996). In 2003, the IFT estimated the Mexican wolf population in the BRWRA to be approximately 50 to 60 wolves, indicating the population is on track with EIS predictions (Arizona Game and Fish Department 2004).

Herein, we: (1) provide a five-year review of the Mexican wolf reintroduction as required by the Mexican wolf final rule (U.S. Fish and Wildlife Service 1998), with the most current data available for the program and (2) highlight additional analysis that provide valuable information to the current reintroduction effort. Additionally, we identify home range and dispersal patterns; analyze release success; document reproduction, population growth, mortality causes, survival and removal rates; assess prey numbers in the BRWRA; investigate livestock depredation patterns, and classify human/wolf encounters in the BRWRA. As per the Final Rule (U.S. Fish and Wildlife Service 1998) we also make a recommendation to continue, modify, or terminate the reintroduction effort based on the best available science presented in this report.

STUDY AREA / REINTRODUCTION AREA

The BRWRA includes all of the Apache and the Gila National Forests (NF) in east-central Arizona and west-central New Mexico, encompassing 17,775 km² (6,845 mi²) (U.S. Fish and Wildlife Service 1996). In addition the White Mountain Apache Tribe has developed a management plan for wolves that adds 6,475 km² (2,500 mi²) for wolves to establish. Elevations range from under 1,220 meters (4,000 feet) in the semi-desert lowlands along the San Francisco River to 3,353 meters (11,000 feet) on Mount Baldy, Escudilla Mountain, and the Mogollon Mountains (U.S. Fish and Wildlife Service 1996). The BRWRA has relatively mild weather with cool summers and moderate to cold winters over most of the higher elevations, and warm year round temperatures in the lower elevations (U.S. Fish and Wildlife Service 1996). Average temperatures range from 43 to 65 degrees Fahrenheit in the higher elevations and lower elevations, respectively (U.S. Fish and Wildlife Service 1996). Yearly precipitation ranges from 30.48 cm (12 inches) in the southern woodlands to 93.98 cm (37 inches) in the mixed conifer forests (U.S. Fish and Wildlife Service 1996). Snow occurs in the higher elevations from December to March. Mixed conifer forests in the higher elevations and semi-desert grasslands in the lower elevations characterize the area, with ponderosa pine forests dominating the area in between (U.S. Fish and Wildlife Service 1996). Potential prey of Mexican wolves include elk, white-tailed and mule deer, and to a lesser extent, pronghorn (*Antilocapra americana*), javelina (*Tayassu tajacu*), and Rocky Mountain bighorn sheep (*Ovis canadensis*) (Parsons 1996). Elk populations were estimated at 15,800 (3.7/km²) and have increased recently (U.S. Fish and Wildlife Service 1996). Deer of both species were estimated at 57,170 (average density 13.36/ km²) and appear to be declining (U.S. Fish and Wildlife Service 1996). Approximately 82,600 cattle and 7,000 sheep graze roughly 69% of the BRWRA and 50% of the allotments are grazed year round (U.S. Fish and Wildlife Service 1996). Other large predators in the BRWRA include coyotes (*Canis latrans*), cougars (*Puma concolor*), and black bears (*Ursus americanus*) (U.S. Fish and Wildlife Service 1996).

METHODS

All adult wolves that were released from captivity or trapped in the wild were radio-collared. Wolves were monitored using standard radio telemetry techniques from the ground and a minimum of once a week from the air (White and Garrot 1990). Location data were entered into the project's database, and along with reports for specific incidents (e.g., depredations, wolf/human conflicts, aversive condition, capture, mortalities, etc.), formed the bases for the analysis contained within this report.

Home Ranges

Aerial locations of wolves were used to develop home ranges (White and Garrott 1990). Home range polygons were based on one year (January-December) of locations evenly distributed across summer and winter seasons for wolves from a given pack (Mladenoff et al. 1995, Wydeven et al. 1995). Some packs held home ranges for several years; thus, we used each pack year as an independent home range sample. To maximize sample independence, individual locations were only recognized for radio-marked wolves that were spatially or temporally separated from other radio-marked pack members. This approach limits potential pseudoreplication among locations.

Wolf home range size in some areas reaches an asymptote at around 30 locations; in such cases increasing the number of locations beyond this level has little effect in increasing estimated home range size (Carbyn 1983, Fuller and Snow 1988). Thus, we elected to use = 30 locations per year as a threshold for analyzing home ranges. Alternatively, some authors have suggested that in recolonizing wolf populations, a larger number of locations (> 79) may be required for home range size to reach its asymptote (Fritts and Mech 1981). To account for this potential sampling bias, we used the fixed kernel (FK) method to estimate wolf home ranges due to its low bias when sample sizes are small (Kernohan et al. 2001). In contrast, previous wolf home range analysis has relied largely on the less stable and less accurate minimum convex polygon (MCP) method (e.g., Carbyn 1983, Fuller and Snow 1988, Burch 2001). FK home ranges derived from smaller samples typically yield more accurate home range size estimates than other estimates that are more dependent on increased sample size to develop accurate home ranges (Seaman et al. 1999, Powell 2000, Kernohan et al. 2001). Thus, we used a 95% FK approach to describe home range sizes due to its improved performance relative to other home range estimators.

Home range polygons were generated at the 95% probability level to represent home range areas used by wolves, and the 50% probability level to represent core use areas (White and Garrott 1990), using the FK method (Worton 1989) with least-squares cross-validation (LSCV) as the smoothing option in the animal movement extension in the program Arcview (Hooge et al. 1999; ESRI, Redlands, CA, USA). Home ranges were only created for wolves that localized in an area and established a territory. Home range sizes were compared with each other and with those in the literature (e.g., Fuller and Murray 1998, Fuller et al. 2003).

Releases and Translocations

We defined releases as wolves released directly from captivity, with no previous free-ranging experience, into the Primary Recovery Zone (Figure 1). Translocations were defined as free-ranging wolves that have been captured and moved from one area to another. This includes wolves that have been temporarily placed in captivity after they have been free-ranging. Release candidate wolves were acclimated prior to release in USFWS approved facilities, where contact between wolves and humans was minimized and carcasses of road-killed native prey species (mostly deer and elk) supplemented their routine diet of processed canine food. Other authors have discussed the captive facilities, genetic lineages of Mexican wolves, and individual wolves chosen for release and thus these methodologies will not be further discussed within the scope of this paper (see García-Moreno et al. 1996, Parsons 1996, Hedrick et al. 1997, Parsons 1998, Brown and Parsons 2001).

Three methodologies of releases/translocations were employed on this project: (1) hard releases in which the wolf or wolves were released directly from a crate to the wild (Fritts et al. 2001), (2) soft releases in which the wolf or wolves were held in a chain link enclosure until they were acclimated to the area (1 to 6 months) and ultimately released to the wild (Fritts et al. 2001), and (3) modified soft releases in which the wolf or wolves were held in a mesh enclosure until they released themselves by tearing through the mesh after a short period (1 day to 2 weeks) of acclimation. A successful release/translocation was considered any wolf that ultimately bred and produced pups in the wild (we included breeding season data from 2004 for wolves released in 2003). We excluded fate unknown wolves (e.g., uncollared released pups, or missing collared animals) from this analysis. We considered each time an animal was released to be an independent sample. The proportion of successful released wolves was compared between releases and translocations and between various methodologies using a chi-squared analysis to limit the number of variables used to analyze in a logistic regression analysis (Hosmer and Lemeshow 2000). We used likelihood-based methods (i.e., ? AIC_c and w_i) as a means to quantify the strength of evidence for models explaining release success patterns (Burnham and Anderson 2000). The dependent variable was a binomial (whether a release was successful or not), while independent variables included: (1) year of release, (2) type of release (e.g., translocation or initial release), (3) method of release, (4) season of release (fall [September-November], winter [December-February], spring [March-May], and summer [June-August]), (5) number of adults in the group, (6) if the group was released with pups or not, (7) status of the wolf (e.g., alpha, sub-adult, or pup), (8) sex, (9) age, (10) time spent in captivity, (11) time spent in the wild, (12) the proportion of the wolves' life spent in the wild , (13) time spent in the acclimation pen, and (14) State (New Mexico or Arizona). Logistic regression provides poor confidence intervals when there are empty cells. Thus, any model with overdispersed data was removed from further consideration (Hosmer and Lemeshow 2000).

Reproduction and Population Growth

Population estimates were determined via howling surveys (Harrington and Mech 1982, Fuller and Sampson 1988), visual observations, and ground radio-telemetry (White and Garrot 1990). A “breeding pair” was defined as an adult male and an adult female wolf that produced at least two pups during the previous breeding season that survived until December 31 of the year of their birth (U.S. Fish and Wildlife Service 1998). Thus, minimum population estimates incorporated the total number of collared wolves, uncollared wolves, and pups, documented as close to December of the year of interest as possible. We attempted to keep at least two marked wolves in each pack within the BRWRA and investigated credible reports in areas where packs were not known to exist.

Pups were generally born from early April to early May within the wild population and opportunistically counted during any period after emergence from the den; however, pups and uncollared wolf counts were based on the latest date in the year in which accurate estimates were available. This period was generally prior to October because pups often become indistinguishable from other uncollared wolves after that. The period following 28 weeks of age in a pup cycle is generally referred to as the slow growth rate (Mech 1970, Kreeger 2003). Although wolves do not quit growing until 12 to 14 months of age, relatively little weight is gained by either sex from 28 weeks to 51 weeks (Kreeger 2003: 0.69 kg females [1.69 pounds], 4.6 kg males [9.2 pounds]). Further, pups were generally closely associated with collared animals prior to October, at den or rendezvous sites. After October, pups gradually become indistinguishable from other uncollared subadult wolves and occasionally disperse or travel separately from the breeders with other uncollared members of the pack.

Population counts were reinitiated at the beginning of each year with the population number counted initially as the number of collared animals. Uncollared adults and pups associated with these collared animals were then estimated throughout the year as described above to develop the subsequent yearly minimum population count. In addition, average pack size for free ranging Mexican wolves, and average litter size for reproducing packs were calculated to compare with other gray wolf populations. In this case, litter size represented the earliest documented count of the pups in a given pack. These observations do not represent the number born in a given year as some mortality likely occurs before initial counts.

Mortality

Wolf mortalities were identified via telemetry and reports from local citizens. We immediately investigated mortalities to determine the status of the wolf. Carcasses were investigated by law enforcement agents and later necropsied to determine the proximate cause of death. We summarized causes for all known deaths. For radio-collared wolves, we calculated mortality rates by the formula $\{1\text{-}[1\text{-}(\text{deaths/radio days})^{\text{days}}]\}$, in this case the number of days was 365 to represent a one-year interval (Trent and Rongstad 1974).

We did not specifically calculate cause-specific mortality rates, because similar to other studies (e.g., Fritts and Mech 1981, Fuller 1989, Pletscher et al. 1997, Bangs et al. 1998) mortality was primarily caused by humans. Management removals may have an equivalent effect as mortality on the free-ranging population of Mexican wolves (see Paquet et al. 2001). Thus, we also calculated cause-specific removal rates for radio-collared wolves. Later in recovery, these removals may actually be deaths, as wolves will be increasingly removed through lethal control (Bangs et al. 1998). Wolves were removed from the population for four primary causes: (1) the wolves were located outside of the BRWRA, (2) cattle depredations, (3) nuisance to humans, and (4) other (principally to pair with other wolves, or move to a better area without any of the other causes occurring first). We considered each time that a wolf was moved to a new location to be a removal, regardless of the status of the animal later in the year (e.g., if the wolf was translocated, or held in captivity). Thus, removal rates were also analyzed using these four causes separately as well as combined by simply substituting the appropriate removal cause for mortalities in the above equation. However, slight corrections are needed in the formula to develop appropriate cause-specific removal and mortality rates (see Heisey and Fuller 1985). Mortality and removal rates were then compared with predictions in the EIS (U. S. Fish and Wildlife Service 1996) and in other wolf populations (Fuller et al. 2003).

In addition, we developed single variable models using Cox's proportional hazards model to identify possible important covariates that influenced the ability of wolves to survive. We developed one model for mortality and one model for removals. The dependent variable was hazard rate (e.g., the mortality or removal rate), while independent variables included: (1) year, (2) status of the wolf (e.g., breeder, sub-adult, or pup), (3) sex, (4) age, (5) time spent in captivity, (6) time spent in the wild, (7) the proportion of the wolves' life spent in the wild, and (8) state (New Mexico or Arizona).

To evaluate how mortality and removal varied across the landscape, we generated mortality and removal rates inside of 1:24,000 quadrangle maps to develop spatially explicit rates. Spatially explicit survival models needed 3 specific data for each quadrangle, (1) number of aerial locations, (2) number of mortalities, and (3) number of removals. Aerial locations were taken on average once every 6.25 days (N = 4,909, Standard Deviation = 5.75). Thus, we calculated the number of radio days by multiplying the number of locations in a given quadrangle by 6.25 days. Quadrangles that contained <5 aerial locations or <30 radio days were considered areas where the data were suspect. We calculated monthly mortality and considered monthly mortality or removal rates above 5 percent (46 percent yearly) as a sink area. Further, we identified quadrangles with rates between 4 and 6 percent as weak sources or sinks. We also identified the last location of wolves that disappeared, to examine the possibility that these wolves were killed in that area. In the scope of these analyses, we attempted to answer the following questions: (1) is wolf mortality substantially higher than projected in the EIS, (2) have any sinks been identified, and (3) have any sources of mortality been significantly higher than expected?

Dispersal

To further evaluate the self-sustaining potential of the Mexican wolf population, we investigated the dispersal/movement patterns of individual wolves on the environment. Wolf dispersal was defined as the time when a wolf permanently left their natal territory (Boyd and Pletscher 1999). To account for wolves that functioned as individual animals following release or translocation, we defined these simply as movements rather than classic dispersals. The distance of travel, age of the wolf, sex of the wolf, direction of travel, and the result of the movement were recorded for each event (i.e., the ultimate fate of the animal). We calculated travel distance and direction through the program Arcview (ESRI, Redlands, CA, USA), either between the central point of successive home ranges, or the distance and direction from the original home range, or release site, to the point where individual wolves died or were captured. The movements were considered successful if the animal ultimately produced pups. The primary purpose of the dispersal/movement analysis was to evaluate the effects of dispersal/movements on population growth within the BRWRA.

Predation

Throughout the year, we searched for native ungulate wolf-kills and scavenged carcasses. After the wolves abandoned the carcass, the crews attempted to determine the proximate cause of death (Roy and Dorrance 1976, Fritts and Mech1981, Mech et al. 1998, Mech et al 2001). Kills were classified as confirmed, probable, or possible based upon a standardized criteria and the preponderance of evidence. Only confirmed or probable kills were used for analysis purposes. Additionally, crews checked each carcass for species, age (calf/fawn, or adult), sex, carcass consumption, and collected bone marrow and mandibles.

We also recorded locations of each kill to relate to the specific game management unit that the kill occurred within. The kill was then referenced to the population estimates of deer and elk within the management unit in which the kill occurred to represent the available prey for the area. For Arizona, data on population estimates for individual management units were based upon deer and elk management summaries in 2003 (Arizona Game and Fish Department, unpublished data). In New Mexico, we used the most recent aerial population survey (New Mexico Department of Game and Fish, unpublished data). Thus, each kill had a specific reference to the population of elk and deer, as well as the bull to cow, and cow to calf ratios. The ungulate estimates were then averaged across all years and game management units to represent available prey. We then compared the documented wolf kills to the available prey estimate and ratios using chi-squared analysis.

One month of a pilot study was completed, in which select packs were located daily from the air to determine the feasibility of a possible winter study to analyze kill rates (Mech et al. 2001, Smith et al. 2004). Ground tracking was done on the days that we were unable to fly. Kills discovered during this process were also included in the analysis. Except for the pilot study, we expected the data collected on ungulate kills to be biased towards larger ungulates (e.g., large elk would more likely be discovered than elk calves or deer). Thus, selection patterns were generally only valid if selection occurred for smaller animals, or alternatively against larger animals.

Prey density estimates were only available for New Mexico. Thus, we were unable to use these densities to estimate the number of wolves the area could support (Keith 1983, Fuller 1989). However, we compared the weight change during repetitive examinations of adult captive Mexican wolves (= 2 years) with the weight gain or loss in repetitive captures of wild adult Mexican wolves to evaluate the ability of the wild wolves to find or kill enough food to maintain their weight. The hypothesis that weight gain or loss was equivalent between wild and captive wolves was tested with a two-sample t-test. Starvation in adults is indicative of food limitations in wild wolf populations (Fritts and Mech 1981, Ballard et al. 1997). Thus, any significant deviation from 0 weight loss between captures would indicate food limitation.

Depredations

Personnel from U.S. Department of Agriculture Animal and Plant Health Inspection Services, Wildlife Services (WS), or the IFT, if WS personnel were unavailable, examined dead or injured cattle, sheep, horses, mules, and dogs within 2 days of discovery to determine cause of death. Domestic animal depredations were classified as confirmed, probable, possible wolf kills, or non-wolf, in adherence with standardized criteria (Roy and Dorrance 1976, Fritts 1982). All depredations were summarized and compared with projections in the EIS and other population of wolves (Bangs et al. 1998, U.S. Fish and Wildlife Service et al. 2003). These comparisons were normalized to represent the number of wolf-caused mortalities relative to 100 wolves within the population.

The effectiveness of the depredation program was evaluated based on: (1) response time from the time of the depredation to the arrival of personnel, (2) the number of documented confirmed or probable livestock kills compared with that predicted in the EIS, (3) the trend in confirmed depredations per 100 wolves, (4) the number of wolves removed per livestock depredation, and (5) the recurrence of depredations by wolves translocated due to previous depredation offenses. We considered a response time within 1day, documented confirmed or probable kills within the rate identified in the EIS, and a decreased or stable trend per 100 wolves as a sign of an effective depredation program. Although, we recognize that not all livestock kills from wolves or any other cause are always documented (Fritts 1982, Bangs et al. 1998, Oakleaf et al. 2003), the most valid analysis must be based on the best available data, which currently are the depredation investigations, rather than unknown livestock loss figures. However, project personnel and permittees spent a significant amount of time to discover dead or missing livestock through monitoring of either the wolves or livestock to discover possible depredations. Further, these biases should be similar to those in other areas in the U.S. where wolves are located, making comparisons between the Mexican wolves and these populations valid.

Human/Wolf Interactions

Human/wolf encounters were summarized based on the categories described by McNay (2002). We found that three of the categories described by McNay (2002) applied to Mexican wolves: aggressive charge, investigative search, and investigative approach. We considered wolf behavior an investigative search when the wolf ignored humans or human activity, an investigative approach described wolves that moved towards people in an inquisitive, non-threatening manner. In an aggressive charge, wolves moved towards people rapidly. Because every aggressive charge by a Mexican wolf occurred when a dog was present we did not feel that any of the other terms used by McNay (2002) were appropriate in these cases (e.g., agonism, predation, prey testing, self-defense, and rabies). Encounters triggered by a dog were considered provoked, while other cases were considered non-provoked (McNay 2002). We also identified whether the interaction resulted in food conditioning (associating food with people). Further, we identified wolves that appeared habituated to humans from the database and encounters. We also identified cases where aversive conditioning was applied. We determined what proportion of the wolves were removed for nuisance behavior and the general trend of wolf/human interactions.

RESULTS

Home Ranges

Home ranges (95 percent fixed kernel probability contour) were established for 18 packs totaling 39 pack years (Figure 2) and averaged 462 ± 63 km^2 (Standard Error [SE]), or 182 ± 24 mi^2. Core use areas (50 percent fixed kernel probability contour) averaged 59 ± 9 km^2 (SE [23 ± 4 mi^2]). Significantly reduced home ranges and core use areas (both log transformed to normalize) were observed for wolf packs during the year of release compared with packs that formed naturally or had been in the environment for more than one year (t = 3.310, P = 0.002, n = 39; and t = 2.610, P = 0.013, n = 39 for home ranges and core use areas, respectively). Home ranges were largely contained within the reintroduction boundary (Figure 2). However, 28 percent (n = 11 out of 39) of the pack yearly home ranges had at least small portions outside of the reintroduction boundary (Figure 2). The area occupied by established wolf packs has continued to increase during each successive year of the project primarily due to an increase in the number of packs (Table 1).

Releases

Ninety wolves were released 130 separate times, including translocations (n = 51, some of the translocated wolves were captured in the wild), and initial releases from captivity (n = 79). Overall, wolves were successful (produced pups in the wild) 26% of all known fate releases. Success was limited (18%) for known-fate animals that were released from captivity (n = 60), while known-fate translocated wolves (n = 46) were more successful (37%, ?^{2} = 4.646, P = 0.031, df = 1). Wolves released in New Mexico (47 % success) were more successful than those released in Arizona (22 %, n = 106, ?^{2} = 5.229, P = 0.022, df = 1). Not surprisingly, adult wolves were more successful (38% success), than were either sub-adults (16 %) or pups (10 % [n = 106, ?^{2} = 7.767, P = 0.021, df = 2]).

Temporal effects also influenced the success of releases, with 2002 (67% success) being the best year for releases, followed by 2000, 2003, 1998, 1999, and 2001 (32%, 29%, 13%, 12.5%, and 11%, respectively [n = 106, ?^{2} = 15.486, P = 0.008, df = 5]). Fall

(3 out of 4 releases successful) and summer (35% success) were more successful periods of release than winter (22%) or spring (18% [n = 106, ?^{2} = 8.221, P = 0.042, df = 3]). Further, successful releases consisted of wolves that spent a greater proportion of their life in the wild prior to release (0.236 ± 0.323 [SD]; unsuccessful released wolves 0.117 ± 0.214; n = 106, t = -2.186, P = 0.031), and a greater number of months in the wild (6.679 ± 8.474 [SD] months; unsuccessful released wolves 3.088 ± 6.2225; n = 106, t = -2.369 P = 0.020). Successful wolves were older at the time of release (3.111 ± 1.765 [SD] years) than unsuccessful animals (2.217 ± 1.739 [SD], n = 106, t = -2.35, P = 0.022). Similarly, successful wolves spent more time in captivity (2.731 ± 1.660 years) than other animals (1.991 ± 1.706, n = 106, t = -2.35, P = 0.022). However, the last result is likely because years in captivity and age were highly correlated (r = 0.956) and age was believed to be the overriding influence. All other significant variables were not highly correlated (r < 0.70), and thus only years in captivity was removed from the model-building process below. All other variables had no significant effect on the successful release of Mexican wolves and were excluded from the model-building process (All P > 0.10).

Logistic regression analysis revealed that the top candidate model for these variables included status of the wolf, the proportion of the released wolf's life spent in the wild, and year of release (Table 2), although there was also support for models with state, season of release, and age (Table 2). The best model described the data (R^2 = 0.223), and predicted unsuccessful released animals well (Specificity = 0.804). However, the model did not predict successfully released animals as well (Sensitivity = 0.454).

Reproduction and Population Growth

The Mexican wolf population grew within the BRWRA from 4 to 55 (Table 3). Initially (1998-2001), this growth came primarily through reintroductions. More recently reproduction has been the primary factor influencing the growth (Table 3). At the end of 2003, 25 radio-collared wolves were free-ranging within the BRWRA. There were also approximately 12 uncollared sub-adult wolves and at least 20 pups documented by the end of September, via howling surveys, visual observations and ground tracking (Table 3). The population consisted of nine packs (groups of wolves that had bred in the past or during the current year; 6 in Arizona and 3 in New Mexico), four groups (two or more wolves traveling together that have not bred), and five lone collared wolves at the end of 2003. In 2003, seven packs (Hawks Nest, Cienega, Saddle, Bluestem, Bonito Creek, Gapiwi, and Luna) produced wild–conceived and wild-born litters. Interestingly, the number of uncollared sub-adults observed during a given year generally tracks the number of pups observed during the previous year (e.g., the sum of pups documented prior to 2003 is 30, while the sum of sub-adults observed is 25 [Table 3]). This trend indicates that a large proportion of the pups that survive until late October are likely to survive to late in the following year.

The number of breeding pairs (a male and a female producing at least 2 pups surviving to the end of the year), pups produced, and mortalities were below the level predicted in the EIS (Figures 3a-3c [U. S. Fish and Wildlife Service 1996]), while the number of released, removed, and population estimates were at or above predicted levels in the EIS (Figures 3d-3f [U. S. Fish and Wildlife Service 1996]).

Compared with other populations of wolves, The Mexican wolf population growth fell between other recolonizing populations of wolves (Figure 4a). Similarly, the number of breeding pairs lay between other studied populations of expanding wolves (Figure 4b). The average litter size for wild-conceived and wild-born pups was 2.1 pups/litter (n = 16, range 1-5), far less than average litter size elsewhere (Fuller et al. 2003). The average number of wolves per pack (packs that had been in the wild for at least 1 year) was 4.8 wolves (n = 16, range 2-11) based on fall estimates.

Mortality

Causes of death for wild Mexican wolves were largely related to humans (vehicle collision [8], illegal gunshot [20], lethal control [1], and capture complications [1]). Other causes of death include one each by dehydration, brain tumor, infection, snakebite, unknown, and a mountain lion attack. Three of the preceding deaths were documented from uncollared wolves. In addition, 5 wild pups succumbed to disease in captive facilities shortly after their capture. Wild wolf mortalities were below the number predicted within the EIS (Figure 3b [U. S. Fish and Wildlife Service 1996]), despite population estimates being similar to that predicted within the EIS (Figure 3f [U. S. Fish and Wildlife Service 1996]).

Although mortality rates were generally slightly lower than the 25% predicted within the EIS, removal rates were much higher than the 10% predicted within the EIS (Table 4 [U. S. Fish and Wildlife Service 1996]). Thus, the overall mortality/removal rate was also much higher than that predicted in the EIS (Table 4 [U. S. Fish and Wildlife Service 1996]). However, the EIS also anticipated that 5 of the 15 wolves released each year were expected to die or be removed relatively quickly and did not incorporate these removals/deaths into the overall estimate. By including these 5 removals in the overall removal rate (as we did in Figure 3d), the overall annual removal rate is 22%. Thus, for comparison with our data (we included data on removal and survival regardless of the timing of the event relative to releases), the removal/mortality level predicted in the EIS is 47% (U. S. Fish and Wildlife Service 1996). The removal/mortality level observed in the wolf population was still higher (62%) than that predicted by the EIS (Table 4 [U. S. Fish and Wildlife Service 1996]).

The greatest single cause of removal was wolves moving outside of the recovery area (Figure 1, Table 5). Further, this is the only removal cause that increased (Table 5). Predictably, nuisance and other removals (generally to pair with a new mate), decreased through time (Table 5). However, the decreasing trend in removal rates for cattle depredations was somewhat unexpected (Table 5).

Cox's proportion hazard models (n = 185 observations, 33 failures, and 33,415 radio days) identified three variables that may be important in predicting which wolves succumb to mortality; (1) year, (2) months in the wild, and (3) the proportion of the wolf's life spent in the wild. Year differences were a result of high mortality during 1998. All other years appear similar and reduced the hazard rate relative to 1998 (1999: 0.237, -1.71, 0.087, 0.046-1.230 [hazard ratio, z, P, 95% confidence ratio], 2000: 0.268, -1.95, 0.051, 0.071-1.005; 2001: 0.285, -2.11, 0.035, 0.089-0.914; 2002: 0.116, -2.89, 0.004, 0.027-0.500; 2003: 0.352, -1.86, 0.062, 0.118-1.05). The greater amount of time in the wild (0.964, -1.76, 0.078, 0.926-1.004 [hazard ratio, z, P, 95% confidence ratio]) and the greater proportion of a wolf's life spent in the wild (0.301, -1.87, 0.061, 0.086-

1.057) also reduced the hazard rate in univariate model building analysis. All other variables did not affect the hazard rate (all $P > 0.15$).

Similarly, the preliminary Cox's proportional hazard models ($n = 185$ observations, 58 failures, and 33,415 radio days) identified the same three variables that may be important in predicting which wolves succumb to removal. Year differences were a result of high removal during 1998, 1999, and 2000. Thus, the hazard rates relative to 1998 were: (1) 1999: 0.714, -0.58, 0.561, 0.230-2.222 [hazard ratio, *z*, *P*, 95% confidence ratio], 2000: 1.197, 0.38, 0.702, 0.477-3.004; 2001: 0.398, -1.73, 0.084, 0.140-1.131; 2002: 0.307, -2.11, 0.035, 0.102-0.919; 2003: 0.409, -1.74, 0.081, 0.150-1.117). The greater amount of time in the wild (0.962, -2.41, 0.016, 0.933-0.993 [hazard ratio, *z*, *P*, 95% confidence ratio]) and the greater proportion of a wolf's life spent in the wild (0.478, -1.70, 0.089, 0.205-1.118) also reduced the hazard rate in univariate model building analysis. All other variables did not affect the hazard rate (All $P > 0.24$).

Depicting survival rates across the landscape ultimately produced a checkered pattern of source-sink areas both within and outside the reintroduction boundary (Figure 5). A total of 218 1:24,000 quadrangles (quads) contained a minimum of one aerial location from 1998-2003. The majority (78 %, $n = 171$) of these quads were sources, however, 63% ($n = 109$) of these source quads were based on suspect data (radio days < 30). The remainder of quads ($n = 47$) were considered sinks due to various causes (Figure 5). However, a proportion of the sink quads were also based on suspect data ($n = 22$).

Dispersal

A total of 45 collared wolves functioned in the environment as individual wolves either immediately following release ($n = 32$) or through natural dispersal ($n = 13$). Only

8 (5 following release and 3 natural dispersal) of these animals ultimately were successful (e.g., bred and produced pups in the wild). The vast majority of single wolves either died (n = 12), or were removed for being outside the boundary (n = 16). Other fates of single wolves included removal for nuisance (n = 5) and cattle depredations (n = 3), wolves still alive but had not bred (n = 2), and missing wolves (n = 2). Three of the successful dispersing animals were ultimately removed. The majority of single wolves were outside the boundary for at least one location (n = 31 out of 45, 68%), even if they were not necessarily removed for this cause. Movement distances were similar between natural dispersal and those movements following release (t = 1.211, p = 0.233), thus these two groups were pooled to analyze movement. Movement distances for lone wolves averaged 87 ± 10 km (54 ± 6 mi (SE)]. Movement distances were similar between male and female wolves (t = -0.951, P = 0.347, n = 44). Neither sex was more prone to display lone movements relative to the released population ($?^2$ = 0.207, P = 0.649, df = 1). Wolves primarily dispersed in a northwest or southeast direction (51%), which is the same direction that the mountain ranges in the BRWRA (Figure 6). Not surprisingly, yearlings dispersed more than adults when compared within the released population ($?^2$ = 8.391, P = 0.004, df = 1).

Predation

Since the projects inception, the field team recorded 72 confirmed or probable kills made by wolves. In addition, wolves were documented to feed or scavenge on 28 other native ungulates killed by other predators, hunters, vehicles, or natural causes. Of the 72 confirmed or probable kills, 90% (n = 65) were elk, indicating a strong preference for elk relative to the ungulate species available (32% elk, and 78 % deer ($?^2$ = 116.192, P

< 0.001, $df = 1$). Mexican wolves were also documented to kill mule deer ($n = 4$), white-tailed deer ($n = 1$), and bighorn sheep ($n = 2$). However, it is unknown if this preference for elk was simply a function of prey size (larger elk being easier for the field team to find than deer due to consumption rates), or alternatively 'a true' selection. Further, areas used by wolves appear to be in high-density elk areas on a game management unit scale. It is unknown what the prey availabilities are on a more local scale.

Wolves selected for calf elk within the population (39% to 23 % of kills and population, respectively), and selected against cow elk (47% to 60% of the wolf kills and population, respectively), while bulls appeared to be selected roughly in proportion to availability (14% and 17%, $?^2 = 5.098$, $P = 0.078$, $df = 2$). This trend would likely be more significant if systematic locations of ungulate kills were more prevalent during the study since wolves appear to be selecting for smaller prey (e.g., calves that are presumably harder to locate) and against larger prey (e.g., cow elk). Further, the seeming preference for elk relative to deer was supported by a recent scat study (Reed 2004).

Adult wolves generally lost weight between subsequent captures in the wild (mean = -1.025 kg, (-2.260 lbs), $n = 40$). This pattern was significantly different from the pattern observed in captivity where wolves generally gained weight (mean = 0.519 kg, [1.146 lbs], $t = -2.647$, $P = 0.009$, $n = 139$). However, the weight loss between capture of wild wolves was not significantly different from 0 ($t = -1.705$, $P = 0.096$, $n = 40$). Both of these results were influenced by two wolves (M190, F189) from the same pack that lost 15.9 kg (35lbs) and 8.39 kg (18.5 pounds) shortly after release. After the removal of these outliers, the difference between wild and captive wolves weight change was not significant (t = -1.599, P = 0.112, n = 129). Further, when these two wolves were removed from the sample the difference from 0 for weight loss of wild wolves was further obscured ((t = -0.994, P = 0.327, n = 38).

Depredations

There were a total of 89 reported incidents within the U.S. Department of Agriculture, Wildlife Services (WS) database between 1998 and 2003. Average response time was 23 hours (minimum 12, maximum 120). Of the cattle confirmed killed by wolves from 1998-2003, 12 were adults and 21 were calves (Table 6). Numbers apparently varied between the WS database and the databases used for previous annual reports (Table 6, compared to Table 7). We chose to use the larger number of reported incidents in each entry between the two databases for additional analysis. Additionally, 6 dogs, 4 horses, and 5 cattle were confirmed injured by wolves, and 3 cattle possibly injured by wolves. In total, 22 wolves were either removed or translocated as a result of livestock depredations. Thus, 1 wolf was removed for every 1.18 confirmed depredations.

Wildlife services personnel were additionally called to investigate possible wolf kills on livestock and dogs that were killed by accidents (9), feral dogs (6), black bears (3), coyotes (5), domestic hybrid wolves (1), mountain lions (2), and unknown (1) causes not related to wolves. Depredation rates (per 100 wolves) on cattle varied from year to year, but were always within the 1-34 range identified in the EIS (Table 8, U.S. Fish and Wildlife Service 1996). There was no clear trend in the data, but 2003 had one of the lowest depredation rates observed during the six years (Table 8). Five of the 18 wolves (27 %) that were translocated following depredations (not necessarily removed for depredations, but had previously depredated) ultimately depredated again. In contrast, 39 of the 83 (47%, released and radio-collared in the wild and never translocated) wolves had caused at least one confirmed (injury or kill) depredation. Further, 9 of the 17 known-fate wolves (53%) that were translocated following depredations ultimately bred and reproduced in the wild. Again, this rate far exceeded the overall release success of 26%, as well as translocation success rate (37%).

Human/Wolf Interactions

We documented wolves displaying limited fear of humans on 30 occasions. The majority of these were considered investigative searches (63%) in which wolves did not approach people, but simply ignored their presence (Appendix I). Most other cases were considered investigative approaches (27%) where the wolf approached a human in a non-threatening manner. Three charge incidents (10%) occurred where wolves were more aggressive. In all of the charge incidents and most of the investigative approaches (5out of8), dogs were involved, and these cases were considered provoked. Similarly, most of the investigative search cases involved dogs (11 of 19) and were considered provoked. Of the 11 non-provoked incidents where wolves displayed a lack of fear of humans, six involved wolves or a wolf considered habituated (Appendix I). One involved a carcass hanging in a deer camp that the wolves fed on, and another was an unknown large canid (a wolf or large dog). Two other incidents involved people riding horses into wolves followed by a brief interaction.

Overall, 9 wolves were removed due to human nuisance behavior 11 different times. Human-nuisance removal rates have declined from 2000-2003 (Table 5). Further, 23 of the 29 known wolf incidents occurred within three months of the release of the animal, including all of the charges that occurred, and all of the non-provoked cases. The remaining six cases all involved domestic dogs.

In 19 of the 29 cases, aversive conditioning and/or removal was applied to attempt to prevent recurrence of the behavior. Several times aversive conditioning helped result in the ultimate success of the wolves with limited future problems (See Appendix I).

DISCUSSION

Home Ranges

Across their geographic range, wolf home range size differences appear to be principally related to prey abundance or biomass (Keith 1983, Fuller 1989, Fuller et al. 1992, Fuller et al. 2003). More specifically, territory size and area per wolf likely relate to the amount of prey biomass available to wolves (vulnerable prey), and thus are also possibly related to prey species (Fuller et al. 2003). Eighteen of our packs established territories between 1998 and 2003, totaling 39-pack years, and averaging 462 ± 63 km^2 (Standard Error [SE]), or 182 ± 24 mi^2. Thus, the average territory size of Mexican wolves most closely resembles the moose-dependent packs in gray wolves studied in the north (see table 6.3 in Fuller et al 2003, and Table 1 in Fuller and Murray 1998). However, territory size was smaller than that of other reintroduced populations that principally preyed on elk in central Idaho, and the Greater Yellowstone Area (Oakleaf 2002). The large territories in these areas, and in the Mexican wolf population may reflect wolf populations that are not subject to density-dependent constraints, or alternatively a general pattern for wolf packs relying primarily on elk (Oakleaf 2002). Further, the heterogeneous distribution of elk may require wolves to maintain a larger territory to encompass sufficient summer and winter ranges of semi-migratory elk.

Regardless of the territory size of Mexican wolves, one conclusion remains clear: Mexican wolves have successfully established and maintained territories within the BRWRA.

Releases

Release success was limited with our population (26% success), particularly for wolves released directly from captivity (18%). These success rates were similar to those of the red wolf population (21 % [Phillips et al. 2003]), but less than those in Idaho (68%) and Yellowstone (77%, Fritts et al. 2001). Similar to both of the previous studies (Fritts et al. 2001, Phillips et al. 2003), releases success did not depend on the type of release (e.g., hard release, soft release, or modified soft release). However, similar to other studies, hard releases tended to produce more movement and less pack cohesiveness (Bangs et al. 1998, Fritts et al. 2001).

Interestingly, our model-building efforts identified 3 primary variables that predicted successful and unsuccessful release efforts: (1) status of the animal (breeder, sub-adult, or pup), (2) the proportion of the released wolf's life spent in the wild, and (3) the year of the release). Red wolves also had reduced success among pups released (Phillips et al. 2003).

Perhaps most importantly the proportion of the wolf's life spent in the wild influences success, with wolves with a greater proportion of time in the wild being more likely to survive and reproduce. Again, this result is similar to those observed in the red wolf program (Phillips et al. 2003). This result also likely influenced the increased success of translocated wolves relative to initial released wolves, and the increased success of wolves released in New Mexico (only translocated animals) relative to

Arizona (translocated and initial released wolves). This variable also might relate to the increased success of the wolf reintroductions in Yellowstone and in Idaho relative to both red wolves and Mexican wolves. Since all of the wolves released in Yellowstone and Idaho were captured in the wild in Canada (Bangs and Fritts 1996, Bangs et al. 1998, Fritts et al. 2001), it is likely that these wolves were more adept initially to adaptation in the wild. However, we agree with other authors (Phillips et al. 2003), that captive wolves can contribute significantly enough to establish a viable wild population and as such are an appropriate source stock to reestablish wolf populations.

Reproduction and Population Growth

Population growth within the BRWRA resembled more closely the growth patterns observed in northwestern Montana and Wisconsin than those observed by the released population of Idaho and Yellowstone. Pack sizes averaged 4.8 wolves per pack, which is generally less than populations in other areas of North America that principally preyed on deer (5.6 wolves/pack), elk (10.2 wolves/pack), moose (6.49 wolves/pack), and caribou (9.05 wolves/pack [see Fuller et al. 2003, Table 6.1],). Similarly, litter size was small for Mexican wolves, averaging 2.1 pups/litter, relative to other populations of gray wolves (see Fuller et al. 2003, Table 6.4). However, the litter size was similar to the 2.8 pups/litter observed in red wolf populations (Phillips et al. 2003, calculated from table 11.4). Several competing hypothesis can be developed from these data.

First, there is a strong correlation between litter sizes and ungulate biomass available for wolves (Fuller et al. 2003). Thus, one hypothesis may be that prey is limiting in the BRWRA. More specifically, wolves in the BRWRA may be limited by the amount of vulnerable prey. Generally, winter snow is ephemeral in the BRWRA and elk can escape the snow during the winter through elevation change (US Fish and Wildlife Service 1996). Other areas where wolves have been studied are much further north where snow is more consistent and deeper across the range, and thus may have profound effects on the vulnerability of the prey to wolf predation (Nelson and Mech 1986, Mech and Peterson 2003, Smith et al. 2004). Thus, one would predict less vulnerable prey in the winter for wolves simply as a result of weather differences between the present study area and other previously studied areas. However, based on the ungulate biomass indexes, Paquet et al. (2001) found that the BRWRA could support about 213 wolves based solely on elk populations, and in theory up to 468 wolves based on all ungulates. Thus, it would appear that there are enough ungulates available to support many more wolves than currently exist. However, it is not just prey numbers that wolves respond to, but rather it is vulnerable prey biomass (Packard and Mech 1980, Fuller et al. 2003).

The second hypothesis that could be posed is that pack size and pup production is a result of historical adaptation with the environment. For example, Bednarz (1988) suggested that Mexican wolves persisted in small family groups of 2-8 individuals, historically. However, McBride (1980) reported mean litter size of 4.5 pups and a mean litter size before parturition of 6.8 pups. Further, the captive population of Mexican wolves has a mean litter size of 4.6 pups (Siminski 2003). Thus, it is likely that more pups are born than that observed in the wild.

The final hypothesis is that wolves released from captivity may be initially less capable of exploiting vulnerable prey and thus have fewer surviving pups when counts are conducted. This may be illustrated by the fact that both the Mexican wolf population and the red wolf population (Phillips et al. 2003) appeared to have relatively low litter size in the wild. In theory, we would expect to be able to test this hypothesis in the near future as more wild born wolves pair and produce pups. Further, the frequent management (see below) of these populations may influence the ability of these wolves to fully exploit their territory. Indeed, the two packs that produced the greatest number of pups in the wild (5) were within their respective territories for approximately 3 years prior to this production.

These competing hypotheses, however, do not change the overriding fact that Mexican wolves have successfully reproduced in the wild within the BRWRA. Further, the population of Mexican wolves has continued to increase as a result of releases, translocations, and more recently, natural reproduction in a consistent fashion to predictions in the EIS (U.S. Fish and Wildlife Service 1996).

Mortality

Mortality rates of Mexican wolves were similar to those of other wolf populations across North America (Fuller et al. 2003). However, the level of mortality that eventually leads to a declining population is likely related to the level of reproduction in the population, and whether breeding wolves are killed (Fuller 1989, Ballard et al. 1997, Fuller et al. 2003). We found low levels of reproduction, and no differential mortality rates among age or status classes. Thus, the Mexican wolf population may be more susceptible to lower mortality reducing the population. Further, this population is essentially a closed population with presumably no opportunity for recovery via immigration. Nevertheless, both the number of mortalities and the mortality rate were below levels identified in the EIS (U.S. Fish and Wildlife Service 1996).

The absolute number of removals and the removal rate were above levels identified in the EIS (U.S. Fish and Wildlife Service 1996). Further, removal rates were consistently higher than mortality rates. Thus, the dominant factor influencing an individual wolves' persistence on the landscape was not mortality, but rather removal. Some forms of removal (those caused by livestock depredations) will likely remain near current levels or vary yearly with environmental factors (Bangs et al. 1998, Mech et al. 1988), as they are a necessary part of any successful wolf-recovery program. Nuisance-related removals are declining, and likely will continue to decline as initial releases from captivity are reduced in the BRWRA (see below). Similarly, other removals (e.g., removals to pair animals, or move wolves to better locations) have dropped since the first few years of the project, with no such removals in the last two years. Despite some removal rates dropping following the recommendations of the three-year review (Paquet et al. 2001), the increasing trend in boundary-related removals remains a concern. Boundary-related removals accounted for fully 36 percent of all removals.

We agree with the findings of other authors (Paquet et al. 2001, Phillips et al. 2003) that the removal of wolves for no other cause than being outside the BRWRA will: 1) increase the cost of the overall recovery program and require that field personnel be allocated to trap individual wide-ranging wolves, 2) lead to the false perception that all wolves can be contained within artificial boundaries, 3) is in direct conflict with management philosophies employed by the Service on other projects (U.S. Fish and Wildlife Service 1994, 1995), 4) excludes habitat that could enhance recovery efforts in concert with the recent reclassification rule for gray wolves in the United States (U.S. Fish and Wildlife Service 2003), and 5) artificially restrict natural dispersal. Dispersal behavior is a vital part of a long-term viable population and colonization of new habitat (Boyd and Pletscher 1999, see below).

Cox-proportional-hazard models identified three covariates (year, proportion of the individual wolf's life spent in the wild, and absolute number of months spent in the wild) that were potentially important in reducing wolf mortality and removal rates. Two of the covariates (year and proportion of the individual wolf's life spent in the wild) were also retained in the release success model discussed above.

Source and sink habitat were distributed both inside and outside the BRWRA. Many cases of suspect data occurred within individual 1:24,000 quadrangle areas due to the random distribution of wolf locations and therefore the number of radio days per cell was similarly uncertain. The number of suspect data cells may suggest that either: 1) we analyze the data using a larger grid size (e.g., 1:100,000 quadrangles), or 2) we interpret the current data and continue to track the changes as data accumulate within individual cells. We chose the latter option, as this is a long-term study with consistent data collection through time. Overall, there appear to be two primary sink areas; the northwest corner of the BRWRA, and the northeastern side of the BRWRA (Figure 5). The overall pattern of source-sink dynamics within the BRWRA suggest that a large area may be required to maintain a viable population of wolves within the southwestern United States (e.g., the more sink areas identified, the larger the area needed to maintain a viable population).

Dispersal

Movement distances for lone wolves averaged 87 ± 10 km (54 ± 6 mi (SE)], with a maximum distance of 271 km (168 miles), with 2 other lone wolves moving over 200 km across the landscape. This mean movement distance was similar to other wolf studies (see Boyd and Pletscher 1999, Table 6). These long distance dispersers crossed interstate highways and the non-essential experimental population boundary, and persisted in various habitat types ranging from the New Mexico/Mexico border (e.g., desert habitat) to north of Flagstaff, Arizona (Figure 6). These wolves were generally far removed for the BRWRA. Further, dispersals appeared to be increasing (Figure 6).

One of the most telling pieces of ancillary information available is that if a wolf moved the average lone-movement distance (e.g., 87 km) from the geographic center of the BRWRA and the White Mountain Apache Reservation in a random direction, it would end outside the BRWRA 66% of the time. Thus, the average dispersing wolf in the ideal spot (e.g., the geographic center of the area that wolves can occupy) would still use areas outside the BRWRA 66% of the time. Indeed, single wolf movements resulted in the majority spending some time outside the BRWRA (68%). Currently, we are documenting more dispersal by wild-born wolves, as one would expect with the increased pup production in recent years. Generally, the wolves disperse between the ages of 1-2 (Fuller 1989, Fritts and Mech 1981), although there is some fluctuation in this pattern depending on prey abundance and wolf densities (see Mech et al. 1998; 116-119, and Boyd and Pletscher 1999, Table 6). However, with many wild-born wolves approaching dispersal age, it is likely that many wild-born wolves (i.e., the segment of the population that has a decreased chance of mortality and removal) will ultimately disperse outside of the BRWRA and be removed if current rules and regulations are not changed.

Predation

Absent human management and mortality, wolf population densities are principally related to prey densities and how vulnerable these populations are to wolf predation (Keith 1983, Fuller 1989, Fuller et al. 2003). Further, wolves tend to kill less fit prey that are predisposed to predation in some form (Mech and Peterson 2003). Documented kills by Mexican wolves were principally elk, and calves were preferred within the elk population. The selection for calves within the elk population is similar to other studied wolf populations (Smith et al. 2004, Husseman 2002). Selection for elk may be related to prey distribution, such that deer are more scattered across the landscape, relative to the more predictable and larger groups of elk (Huggard 1993, Mech and Peterson 2003). The limited number of wolves that currently exist in the BRWRA suggest that their impacts on the ungulate populations are minimal. Current research investigating kill rates in winter (through daily aerial flights, and GPS collars), and summer (through GPS collars) should allow a better evaluation of predation patterns in the future and help elucidate the overall impact of wolves on ungulates.

Although the few pups produced per litter may be of some concern (see discussion above), the majority of adult wolves maintained their weight in the wild, although there were two notable exceptions. There were no wolf mortalities from intraspecific strife, and we found no Mexican wolves dead from starvation. High levels of intraspecific strife, or any indication of starvation would be indicative of a food-stressed environment (Fritts and Mech 1981, Ballard et al. 1997). The lack of evidence that these indicators occurred combined with the suggested wolf population level that ungulates in the area could support (Paquet et al. 2001), leads to the conclusion that there are ample vulnerable prey in the area to support wolves.

Depredations

Healthy populations of ungulates throughout the United States have allowed wolf recovery to occur. As a result of these ungulate populations, in most areas where wolves and livestock coexist in North America, the proportion of livestock lost to wolves is generally low (Bjorge and Gunson 1985, Fritts et al. 1992, Bangs et al. 1998, Fritts et al. 2003, Oakleaf et al. 2003).

Fritts et al. (2003) noted that most of the livestock losses in previously studied areas are killed during the summer grazing season. At these times of year, wolves and livestock are often located in remote forest grazing areas (Oakleaf et al. 2003). The pattern is markedly different in the BRWRA. Indeed, many of the remote grazing areas are year-round forest grazing operations (e.g., cattle calve, raise their young, and are present in remote areas year-round), compared with summer operations in northern areas. Newborn livestock and younger calves in remote locations may be the most vulnerable segment of the cattle population (Oakleaf et al. 2003).

One credible hypothesis regarding the question of why wolves do not kill more livestock given the availability of the relatively vulnerable animals has been that wolves react differently to livestock than to wild prey due to the limited exposure of wolves to livestock (e.g., livestock are only present during a portion of the year in more northerly latitudes [Fritts et al. 2003]). Following this hypothesis then, one would expect that where wolves and livestock coexist year-round, depredations would be greater and the number of vulnerable livestock in the area would be greater. However, depredations are currently occurring at only a slightly higher rate in the BRWRA, despite 3-4 times greater time for cattle and wolves to interact (Table 8). Thus, depredations by wolves have remained within the levels identified within the EIS (U.S. Fish and Wildlife Service 1996). Further, the Mexican wolf program has met every measure of a successful program identified previously.

Another pattern that is markedly different than that observed in other wolf recovery areas (see Bangs et al. 1998) is the relative success of translocating previously depredating wolves. We found that these wolves contributed to recovery and caused fewer depredations than the average for the entire population. Fritts et al. (2003) suggested that typically when wolves depredate on cattle, they do not depredate again for several weeks, if at all. Even in the northern Rockies recovery area the pattern of wolves translocated for depredations ultimately depredating again was generally only observed for the northwestern Montana area (Bangs et al. 1998), with translocated wolves in Idaho showing far fewer repeat depredations. This pattern may relate to the ability, both in Idaho and the BRWRA, to translocate wolves into unoccupied wolf habitat that is free of livestock.

Human/Wolf Interactions

Overall, Mexican wolves were involved in 30 incidents of apparently fearless behavior. However, the majority of these incidents (79%) involved wolves that had recently been released and had spent limited time in the wild, with the remainder of the cases involving dogs. Similar to other areas where wolves and humans interact, aggressive behavior by wolves in the Southwest towards humans with dogs were the most frequent occurrence (McNay 2002, Fritts et al. 2003). Wolves have been documented to kill domestic dogs virtually everywhere that the two coexist (Bangs et al. 1998, Fritts et al. 2003), including this project. Wolf attacks on dogs may sometimes result in a temporary loss of their flight response to humans (McNay 2002, Fritts et al. 2003). In the three cases that a Mexican wolf or wolves appeared aggressive and charged towards humans, dogs were in the area and the aggression appeared to be focused on the dogs rather than the humans.

During the six years of the Mexican wolf project, we have not documented, nor have there been reported, any instances in which wolves have came into physical contact with humans. However, wolves released from captivity may be more prone to initial fearless behavior towards humans despite minimizing human contact in captivity and developing appropriate standards for selecting individual wolves to release (see Parsons 1998, Brown and Parsons 2001). Aversive conditioning and or removal resolved all problems in a relatively quick fashion. The paucity of documented wolf attacks in North America suggests that wolves rarely attack people there (McNay 2002). However, wolves in protected populations generally are less fearful of humans than those in exploited populations (McNay 2002). Thus, managers should continue to closely monitor initially released wolves and initiate aggressive aversive conditioning, or removal if appropriate, when wolves are near humans.

MANAGEMENT IMPLICATIONS

Many of the goals and projections described in the EIS (U.S. Fish and Wildlife Service 1996) have been either exceeded or met. Most notably, population counts are at the projected levels, with mortality being lower. Thus, the overall reintroduction program appears to be functioning at least as well as projected and should be continued. However, some improvements can be accomplished.

First, both the number of released, and the number of removed wolves have exceeded the levels projected within the EIS (U.S. Fish and Wildlife Service 1996). These higher levels are largely a result of the guidelines in the original Final Rule for the BRWRA that require wolves to be removed if they establish a territory wholly outside the recovery area, or at the request of private landowners for wolves on their lands outside the recovery area (U.S. Fish and Wildlife Service 1996). These policies conflict with normal wolf movements (see Boyd and Pletscher 1999, Table 6), and differ from the management of wolves elsewhere in the United States (U.S. Fish and Wildlife Service 1994, 1995). Thus, we recommend that the project modify the final non-essential experimental rule to allow wolves to occur in areas within the southwestern distinct population segment (SWDPS) of the gray wolf (U.S. Fish and Wildlife Service 2003) where they do not conflict with livestock or humans. This step alone would reduce the number of removals by 36% and bring removal rates into congruence with the predictions within the EIS (U.S. Fish and Wildlife Service 1996).

Data suggest that animals having lived in the wild for a larger proportion of their life are more likely to be involved in a successful release, and are less likely to succumb to mortality or removal. Thus, our second recommendation is that wolves with wild experience generally continue to be translocated after their first removal event, except in extreme situations. Further, before initial release, wolves would likely benefit from a large experience center in a wild, protected area similar to those used for red wolves (Phillips et al. 2003). Through this process, initial released wolves may ultimately have reduced interaction with humans. This recommendation may not be accomplished soon enough for the BRWRA, but could be implemented with other reintroduced populations.

Our third recommendation is that more care needs to be placed on appropriate centralized databases. The current databases were sometimes difficult to interpret, and in disagreement among cooperating agencies. This is particularly striking considering that one of the most important databases (depredations) indicated differences relative to the number of confirmed depredations. Further, following the three-year review, record-keeping on wolf/human interactions was largely absent except for scattered journal entries and the recollection of employees.

Both the environment in the BRWRA and many patterns within the Mexican wolf program differ from those of other areas and programs. Thus, ample research opportunities exist to compare data with the more northerly and better-studied populations of gray wolves. As such, we recommend that more research opportunities be explored and funded to provide insight into the overall Mexican wolf program.

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Table 1. Average home range and core use areas documented for Mexican wolves in the Blue Range Wolf Reintroduction Area from 1998-2003.

Year	No. Packs	Average Home Range Size (km^2)[a]	Average Core Use Size (km^2)[b]	Total Area Packs Occupied By Packs (km^2)
1998	2	150	19	301
1999	5	118	21	590
2000	5	575	71	2872
2001	6	479	52	2876
2002	9	299	37	2691
2003	12	725	92	8700

[a] Average home range size was based upon 95% fixed kernel estimators.

[b] Average core use size was based upon 50% fixed kernel estimators.

Table 2. Models supported within the analysis for successful Mexican wolf releases. Models were based on 28 successes (e.g., wolves that bred and produced pups in the wild) and 78 failures.

Model	AIC_c	? AIC	w_i
Status[a] + Wild/Life[b] + Year	113.71	0.00	0.334
Status + Wild/Life	114.64	0.93	0.210
Status + Season[c] + State[d]	115.67	1.96	0.125
Age + Wild/Life + Year	116.69	2.98	0.075
Year + Status	116.84	3.13	0.242
Age + Wild/Life	117.02	3.31	0.064
Status + Season	117.49	3.78	0.050
Translocation[e] + Status	119.25	5.54	0.021
Status + Months in the Wild	119.98	6.27	0.015
Age + Season	119.99	6.28	0.014
Season + State	120.49	6.78	0.011
Year	120.73	7.02	0.010

[a] Status of the wolf (breeder, sub-adult, or pup).

[b] The proportion of the wolves life spent in the wild at the time of the release

[c] Season of release for the wolf (fall, winter, spring, or summer).

[d] State of release of the wolf (New Mexico or Arizona).

[e] Either translocation or initial release.

Table 3. Minimum population estimates of Mexican wolves in the Blue Range Wolf Recovery Area based on visual counts as well as removals and releases.

Year	Released[a]	Removed[b]	Mortalities	Pups[c]	Collared	Uncollared[d]	Estimate[e]
1998	16	6	5	0	4	0	4
1999	23	12	2	8[e]	7	0	15
2000	31	23	4	5	15	2	22
2001	21	10	9	3	18	5	26
2002	16	7	3	21	25	3	42
2003	23	14	13	20	23	12	55
Total	130	58	36	57		25	

[a] Based on the number of initial releases and translocations of Mexican wolves. Any animal that was captured and moved was considered a new translocation. Thus, a single wolf may have been released several times in a given year.

[b] Wolves captured and moved. We considered it removal regardless of whether the animal was re-released or not. These estimates include wolves that were removed and died in captivity (not included in mortalities), animals that were lethally removed (1 in 2003, included in mortalities), and animals that died during capture (1 in 2002, included in mortalities).

[c] Based on the number of pups observed in the wild as close as possible to the end of the year. Radio-collared pups (n= 7) are also included in the collared end of the year count for 2002.

[d] Uncollared sub-adult wolves (not pups of the year) documented by the wolf project as close to the end of the year as possible. These numbers do not include missing wolves.

[e] Minimum population estimate for the end of the year. These numbers represent the cumulative of pups, collared and uncollared animals observed near the end of the year for any given year.

Table 4. The mortality rates and removal rates of Mexican wolves in the Blue Range Wolf Recovery Area. This table also includes the failure rate of wolves in the wild which would consider how often wolves are either removed or die. All rates were calculated using the program Micromort (Heisey and Fuller 1985). The numbers in parenthesis represent the absolute number of radio-collared wolves that were removed or died during a given time frame by cause.

Year	N[1]	Removal Rate	Mortality Rate	Failure Rate
1998	13	0.50 (6)	0.41 (5)	0.91 (11)
1999	14	0.49 (6)	0.16 (2)	0.65 (8)
2000	31	0.68 (19)	0.14 (4)	0.82 (23)
2001	30	0.29 (9)	0.26 (8)	0.55 (17)
2002	34	0.27 (7)	0.11 (3)	0.38 (10)
2003	37	0.30 (11)	0.27 (10)	0.57 (21)
Total[2]	75	0.40 (58)	0.22 (32)	0.62 (91)

[1] N represents the total number of collared wolves in the population during the full year. Some wolves had more radio days than other wolves.

[2] Total represents the summation of all mortality or removal events divided by the radio days and raised to the 365 power, to describe the average yearly mortality, removal, and failure rates.

Table 5. Removal rates based on Heisey and Fuller (1985) of Mexican Wolves within the Blue Range Wolf Recovery Area by cause. Removal rates were calculated using the program Micromort (Heisey and Fuller 1985), where *n* represents the number of radio collared wolves removed by cause. The numbers in parenthesis represent the absolute number of radio-collared wolves that were removed during a given time frame by cause. Some wolves were translocated immediately following removal, while others were placed in captivity, or translocated at a later date.

Year	N[1]	Removal Rate	Boundary[2]	Nuisance[3]	Cattle[4]	Other[5]
1998	13	0.50 (6)	0.08 (1)	0.17 (2)	0 (0)	0.25 (3)
1999	14	0.49 (6)	0 (0)	0 (0)	0.245 (3)	0.245 (3)
2000	31	0.68 (19)	0.18 (5)	0.18 (5)	0.14 (4)	0.18 (5)
2001	30	0.29 (9)	0.13 (4)	0.06 (2)	0.06 (2)	0.03 (1)
2002	34	0.27 (7)	0.15 (4)	0.04 (1)	0.08 (2)	0 (0)
2003	37	0.30 (11)	0.19 (7)	0.03 (1)	0.08 (3)	0 (0)
Total	75	0.40 (58)	0.15 (21)	0.07 (11)	0.10 (14)	0.08 (12)

[1] N represents the total number of collared wolves in the population during the full year. Some wolves had more radio days than other wolves.

[2] The removal rate of wolves that moved outside of the Blue Range Wolf Recovery Area (See Figure 1).

[3] The removal rate of wolves that displayed poor behavioral characteristics and were located close to humans.

[4] The removal rate of wolves that depredated repeatedly on livestock

[5] Wolves removed to pair with other wolves or to relocate to a better area prior to other causes of removals being initiated.

Table 6. Number of livestock and dogs confirmed (Conf.), probably (Prob.), or possibly (Poss.) killed by Mexican wolves during each year (1998-2003). Information from the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services Database.

		Cattle		Dog	Sheep	Horse
Year	Conf.	Prob.	Poss.	Conf.	Conf.	Poss.
1998	0	0	0	1	0	0
1999	5	0	5	0	0	0
2000	1	0	2	0	1	0
2001	3	0	3	0	0	0
2002	9	0	0	1	0	1
2003	3	4	2	0	1	0
Total	21	4	12	2	2	1

Table 7. Number of livestock and dogs confirmed (Conf.), probably (Prob.), or possibly (Poss.) killed by Mexican wolves during each year (1998-2003), according to annual reports from 1998-2003 based on the U.S. Fish and Wildlife Service Database.

	Cattle			Dog	Sheep	Horse	
Year	Conf.	Prob.	Poss.	Conf.		Conf.	Poss.
1998	0	0	0	1	0	0	0
1999	5	0	**4**	0	0	0	0
2000	1	0	2	0	1	0	0
2001	**6**	0	**5**	0	0	**1**	0
2002	**11**	0	**1**	1	0	0	**0**
2003	3	4	**1**	0	1	0	**1**
Total	**26**	4	**13**	2	2	**1**	1

Table 8. Number of cattle confirmed killed by wolves, wolf population estimates, and number of cattle killed per 100 wolves in 5 states. Data represent the years 2000-2002 for all states except Arizona/New Mexico, which includes 1998-2003). We used annual USDA-APHIS, Wildlife Services annual reports from each state to determine the number of cattle killed by wolves. Kills were verified by specialists trained in field necropsies to determine cause of death and do not reflect those animals that were determined to be probable or possible kills.

State/Year	Cattle Killed	Wolf Population	Cattle Killed/Wolf Population x 100
Montana 2000	14	97	14
Montana 2001	12	123	10
Montana 2002	20	183	11
Montana Mean	15.33	134.33	11
Wyoming 2000	3	159	2
Wyoming 2001	18	189	10
Wyoming2002	23	217	11
Wyoming Mean	14.67	188.33	8
Idaho 2000	15	187	8
Idaho 2001	10	251	4
Idaho 2002	9	263	3
Idaho Mean	11.33	233.67	5
AZ/NM 1998	0	4	0
AZ/NM 1999	5	15	33
AZ/NM 2000	1	22	5
AZ/NM 2001	6	26	22
AZ/NM 2002	11	42	27
AZ/NM 2003	3	55	5
AZ/NM Mean	4.33	27.33	15.84

Figure 1. The Mexican wolf Blue Range wolf reintroduction area and non-essential experimental designated area. It is important to note that any wolf that establishes a territory wholly outside of the secondary or primary recovery zone, or the Fort Apache Indian Reservation are removed due to boundary issues (9,000 sq miles).

Figure 1. The Mexican Wolf Blue Range Wolf Recovery Area in Arizona and New Mexico.

Figure 2. Home ranges established by Mexican wolves from 1998-2003. Home ranges in the Fort Apache Indian Reservation were not shown at the tribe's request.

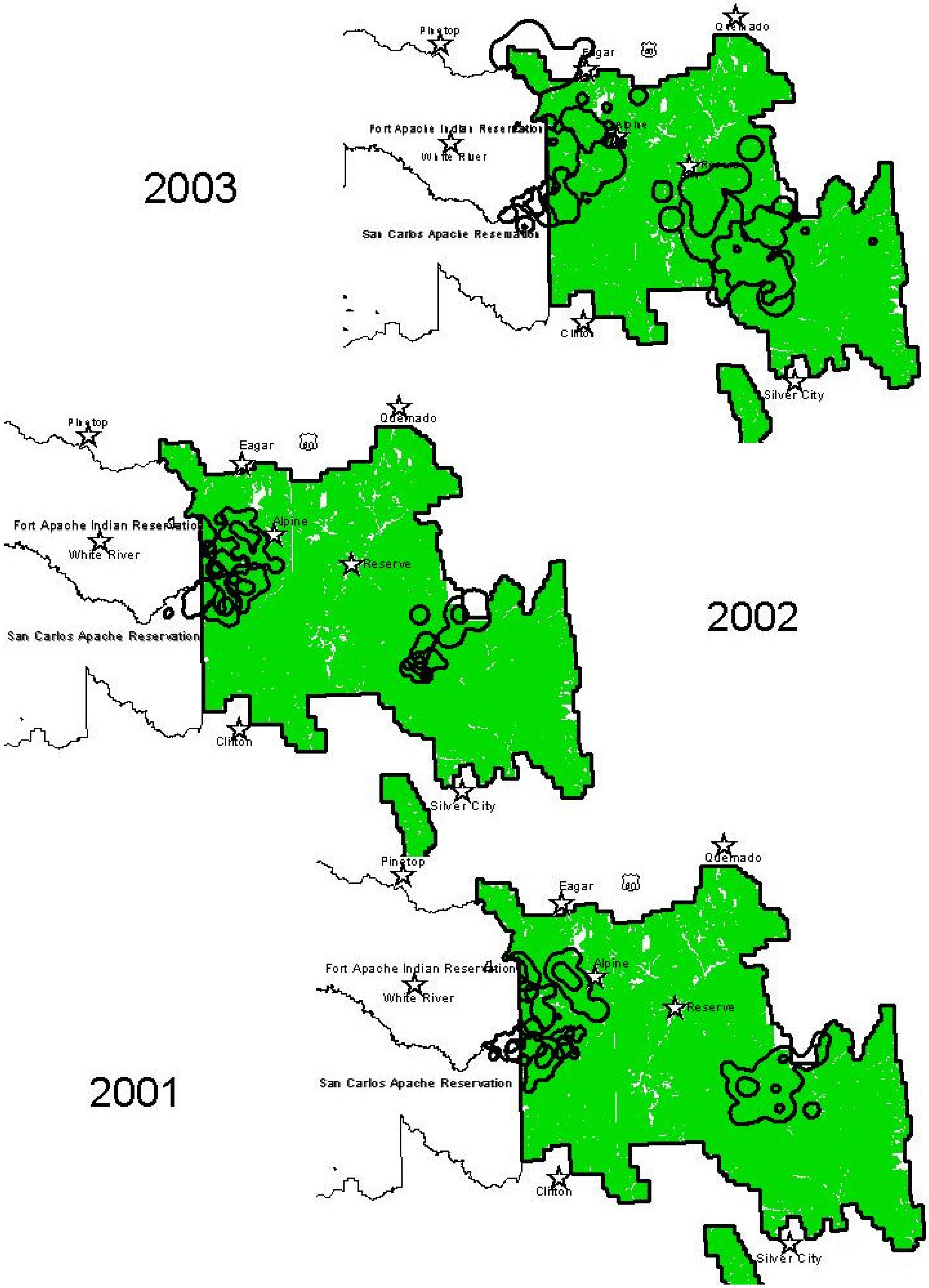


Figure 2. Cont.

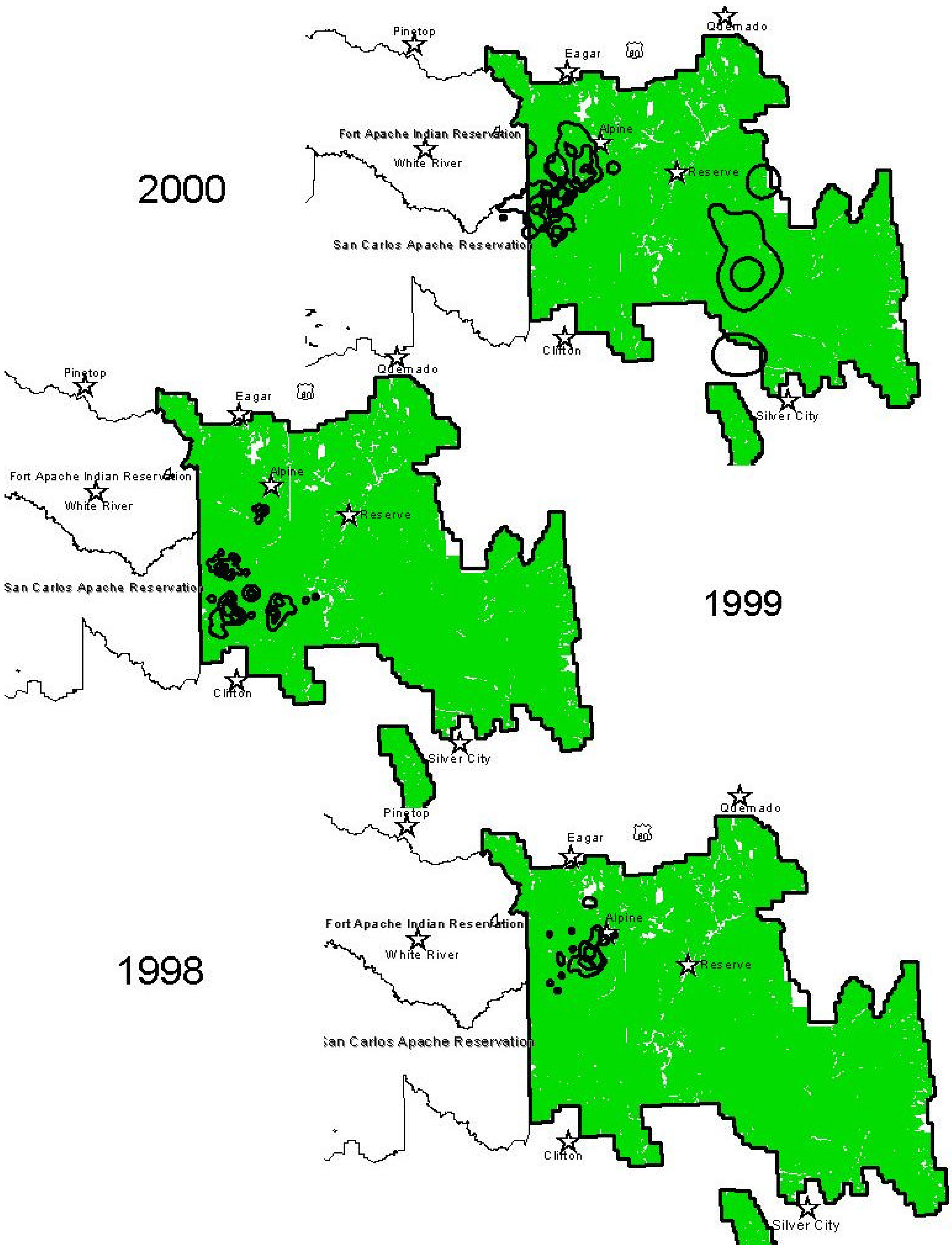
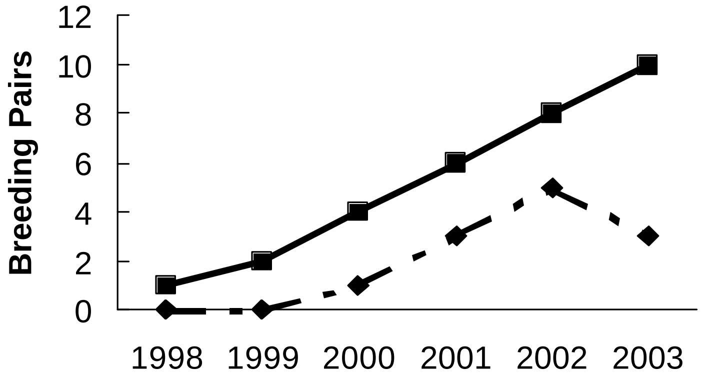


Figure 3. Observed (dashed line) and predicted (solid lines) Mexican wolf population trends in the EIS (U.S. Fish and Wildlife Service 1996).

A:



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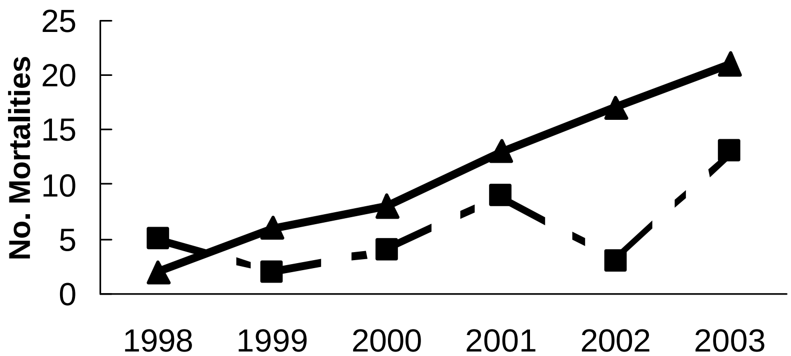

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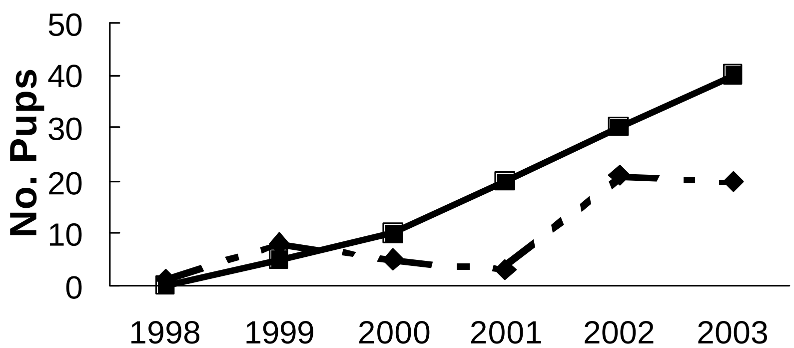

Figure 3 Cont.

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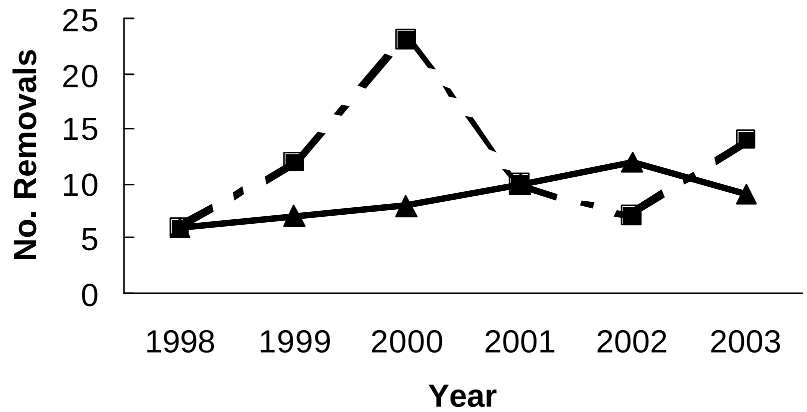
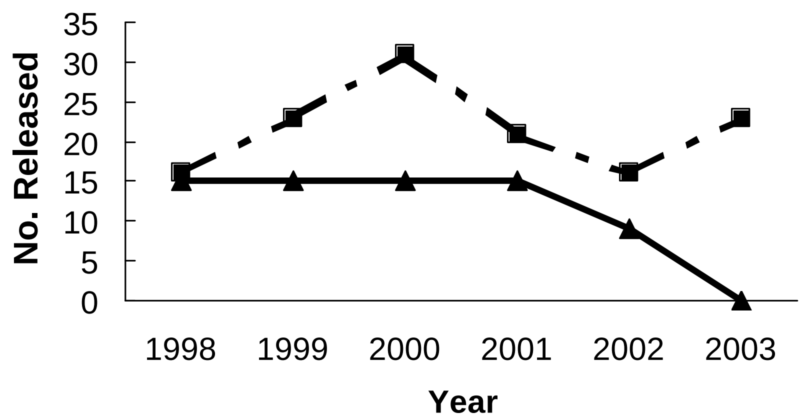


E:



F:

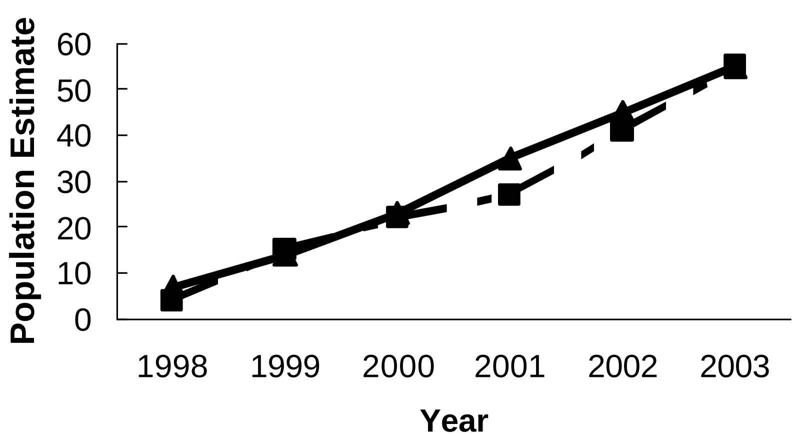
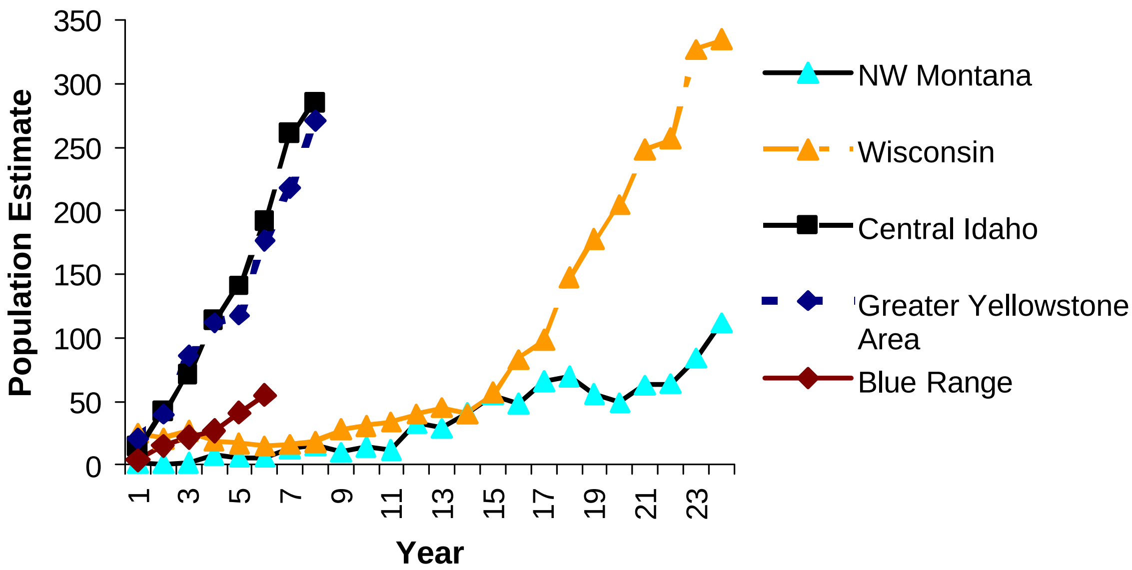


Figure 4. Population trends observed with Mexican wolf and other reintroduced or recolonizing gray wolf populations in the United States.

A:



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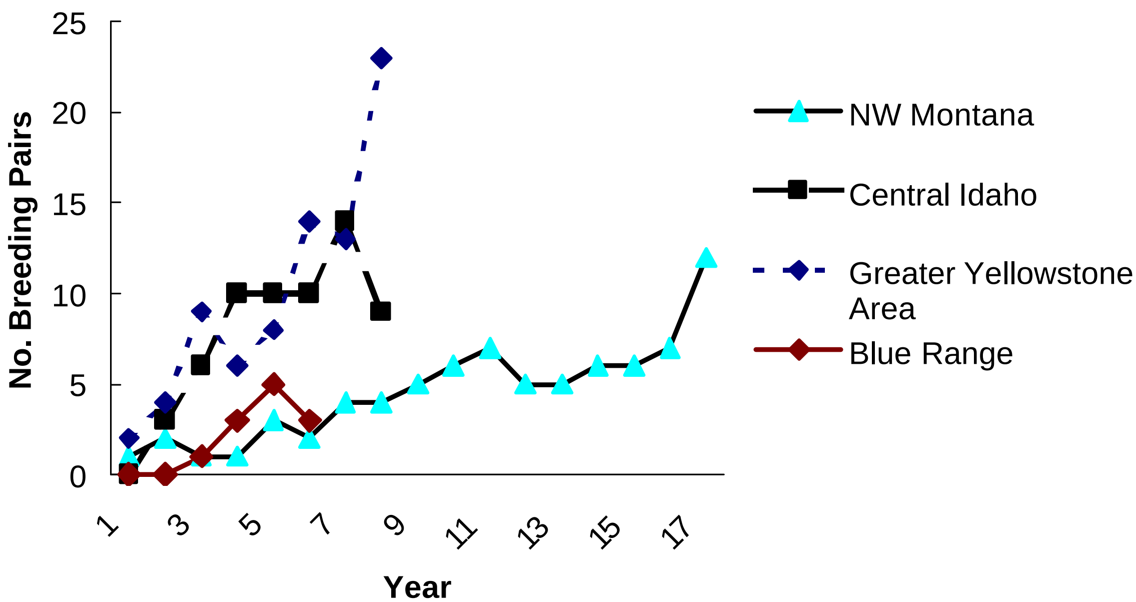


Figure 5. Source-sink dynamics in the Blue Range Wolf Reintroduction Area. Inset figures identify areas with multiple causes for sinks (see the legend in the bottom left corner).

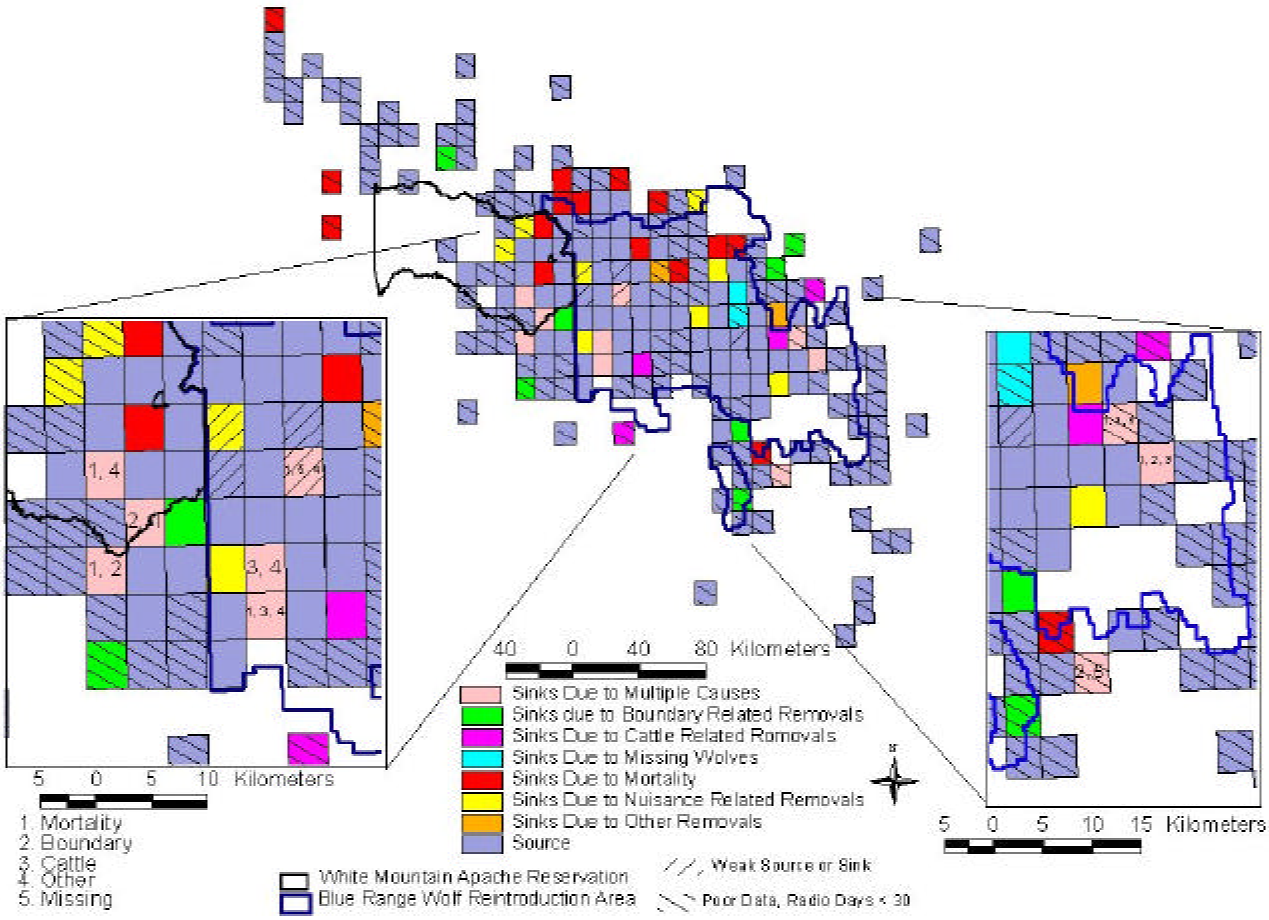
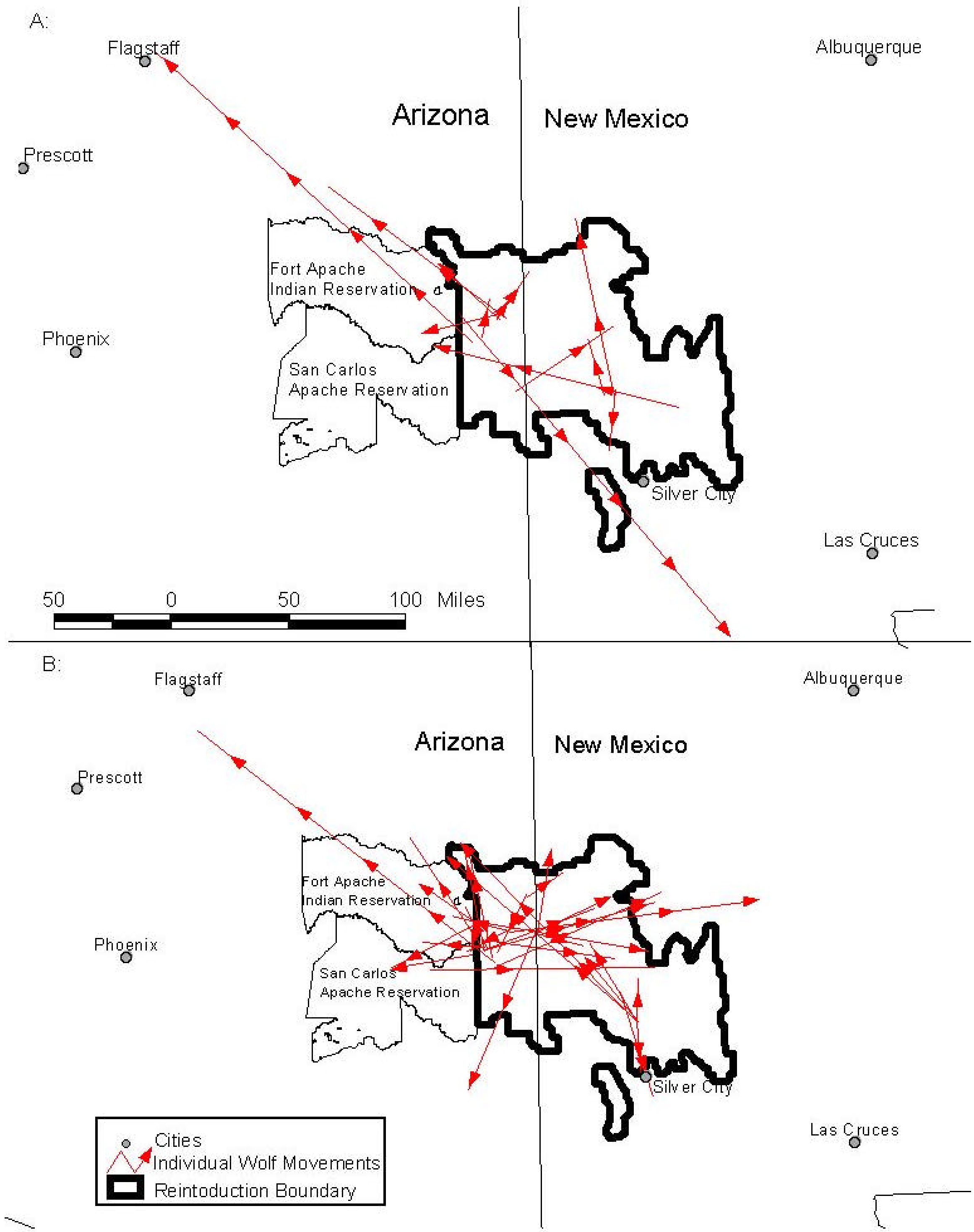


Figure 6. Movement patterns of individual Mexican wolves in the Blue Range Wolf Reintroduction Area from 1998-2000 (A), and 2001-2003 (B). Each line represents one dispersal/movement of a lone wolf.



APPENDIX I—Wolf/Human Interactions

Event	Date	Wolves Involved	Dog presence (Provoked)	Classification (Bolded Items Indicate Field Team Actions)	Memo
1	April 28, 1998	156	Yes	Charge/ Investigative approach, Dead	Wolf 156 was shot by a camper who feared for his family's safety when the wolf came into their camp and attacked their dog
2	May 8, 1998	494		Investigative Search, **Aversive Conditioning** Habituated, **Removed**	494 became a nuisance frequenting the town of Alpine from 5/8/98 through 5/28/98 and was permanently removed from the wild.
3	May 1999 to August 1999	208,562, 191	Yes	Investigative approach, Aversive Conditioning Removed for livestock depredation	208,191 (alpha female) and 562 (all recently released) approached ranch house with loose dogs, dogs chased wolves, wolves chased dogs, dog got bit. Owner ran wolves off, one wolf M208 followed owner back towards house. F191 subsequently denned and several more encounters with the dogs occurred near the house. Attempts at aversive conditioning were mostly unsuccessful. All wolves removed in August due to livestock depredation.
4	January 6, 1999	166, 482		Investigative search, Food Conditioning	Campbell Blue pair jerked down a deer carcass hanging in some archery hunter's camp
5	January 5, 2000	522	Yes	Investigative Search, **Removed**	Female 522 hanging around hunters camp interacting with dogs. Trapped and put in acclimation pen to hold through hunting season.
6	February 6, 2000	522	Yes	Investigative Search, **Removed**	Interacting with dogs at a ranch house immediately after release.

Event	Date	Wolves Involved	Dog presence (Provoked)	Classification (Bolded Items Indicate Field Team Actions)	Memo
7	April 14, 2000	166, 518	Yes	Charge, **Removed**	Permittee reported a very aggressive encounter with the Campbell Blue pair with the female 518 bumping his horse and passing under it. Wolves also attacked one of his dogs. They followed him to the cabin and he held up in it until the wolves left.
8	May 16, 2000	208, 191	Yes	Investigative Approach, **Removed**	A female jogging with 2 dogs when 2 wolves approached—wolves clearly interested in dogs. Renee scares wolves away.
9	June 1, 2000	624		Investigative Search. **Removed**	Frequenting a ranch house
10	July 16, 2000	624	Yes	Investigative Search. **Removed**	Frequenting a ranch and exhibiting playful behavior with a dog.
11	August 20, 2000	511, 509, 587, 590	Yes	Aggressive Charge, Habituated, **Aversive Conditioning**	Camper and his cocker spaniel were out in the middle of the meadow behind his trailer when 4 wolves (most likely Francisco) came tearing out of the woods towards them. Camper fired 1 shot in front of the wolves but they kept coming ("one with a look of fierce determination"). He fired a second shot as they got closer and they reared away. He was very upset at the situation and felt that they were a danger to both people and animals/pets. Later that week, people camped nearby observed several wolves and pups resting in the shade under and around camper's trailer. At the time he was inside watching golf with his dog, unaware that the wolves were outside. He was irate when he learned of the incident, stating that this was not the behavior of wild animals and concerned about what would have happened had he or his dog come out of the trailer.

Event	Date	Wolves Involved	Dog presence (Provoked)	Classification (Bolded Items Indicate Field Team Actions)	Memo
12	August 24, 2000	511, 509, 587, 590		Investigative Approach, Habituated, **Aversive Conditioning**	Camper observed Francisco (and Cienega) on multiple occasions during his time camping at Double Cienega. Sometimes they came right through camp < 5 ft of him taking pictures, although the pups seemed more skittish. He saw them other times farther away within the campground or out in the meadow.
13	September 25, 2000	590		Investigative Search, Habituated, **Aversive Conditioning**	Yearling male 590 hanging around Double Cienega Campground for the majority of the day
14	September 29, 2000	511, 509, 587, 590		Investigative approach Food Conditioning, **Aversive Conditioning** Habituated	5-6 people camped in Double Cienega from about 8/21-8/30/00. Throughout the week they interacted with Francisco. On multiple occasions they howled the in, chased them on ATV's, left food out and shot blunt arrows at them. The wolves also chased their horses, mules, and the people in the ATVs. They were informed that this behavior was not acceptable, and we explained that what they were doing may possibly have negative effects on the wolves behavior. On 8/30/00, while speaking with the hunters, IFT personnel observed the wolves chasing the mules. He then hazed the wolves by running at them and throwing rocks. They ignored him. We first spoke with the group on about 8/23/00. IFT personnel informed them about the Mexican Wolf Recovery project, the presence of wolves in the area, and proper behavior with respect to wolves (e.g. Do not leave out food; keep an eye on mules/horses; if you see the wolves, yell and throw rocks at them. We also told them to let us know if they had any interactions with the wolves.

Event	Date	Wolves Involved	Dog presence (Provoked)	Classification (Bolded Items Indicate Field Team Actions)	Memo
15	October 1, 2000	Unknown		Investigative Search, Food Conditioning	At about 0440 Homeowner went out the front door on the porch and observed an animal in the driveway. At first he thought it way a German Shepard, then by the color and size he realized it was a wolf. He scared it away and it headed west down the road. He tried to follow it in his truck but lost track of it. When he got back to the house it was by the back door eating out of the dog dish. He scared it away again and it ran behind the house between the animal pens and the barn. He checked the dog dish and it was empty. He was not sure if there had been food in it or not. IFT personnel responded to the call made the landowners sister. We looked at the area where the report was taken and observed large canid tracks in the driveway and yard. (track size = 5 x 3 ½", in the sand and gravel). No other tracks were found in area. IFT personnel returned on 10/2 at about 0500.
16	November 2001	M580; Wildcat	Yes	Investigative Search, **Removed**	Point of Pines, San Carlos Apache Reservation. Wolf frequenting residential area. Many domestic and feral dogs in area. Wolf was captured by helicopter.
17	Summer 2002	Bluestem		Investigative Search, Habituated	In the vicinity of PS Knoll, Apache National Forest, Arizona. Permittee encountered a wolf while monitoring cattle on horseback. Shouted at wolf, however there was no response by the wolf. Wolf eventually left the area. Wolf did not approach Permittee, therefore, most likely displaying curious behavior. Unknown if a dog was with Permittee or not.

Event	Date	Wolves Involved	Dog presence (Provoked)	Classification (Bolded Items Indicate Field Team Actions)	Memo
18	Summer 2002	Bluestem	Yes	Investigative Search, Habituated	In the vicinity of PS Knoll, Apache National Forest, Arizona. Permittee encountered a wolf while monitoring cattle on horseback; dog present. Shouted at wolf; wolf vacated area. Wolf most likely displaying curious behavior, possibly due to the presence of the dog.
19	Summer 2002	f637; Bluestem		Investigative Search, **Aversive Conditioning** Habituated	U.S. Forest Service reported a wolf walking down the Big Lake campground road, in Apache National Forest, Arizona. Project personnel located wolf f637 150 yards south of active campsites. Project personnel responded that same day and fired/hit the wolf with a rubber bullet. Wolf vacated area.
20	Summer 2002	f637; Bluestem	Yes	Investigative Search, Habituated, **Removed**	White River, Forte Apache Indian Reservation, Arizona. Project personnel located f637 around White River for a couple of days. The wolf was seen traveling adjacent to residential area. Project personnel attempted to haze the wolf from these areas. Many domestic and feral dogs in area. Wolf observed interacting with resident's dog about 8 miles to the north of White River in the yard of a private residence. Wolf was captured and returned to captivity.
21	Summer 2002	Bluestem	Yes	Investigative Search, **Aversive conditioning**	Sprucedale Ranch, Apache National Forest, Arizona. No direct interaction between wolves and humans, but wolves were observed from the ranch headquarters. Female domestic dog with pups present. Female dog killed by wolves after attempting to chase wolves away from area. Project personnel intensively monitored wolves, aversively conditioning wolves when located in area. Wolves eventually stayed away from ranch.

Event	Date	Wolves Involved	Dog presence (Provoked)	Classification (Bolded Items Indicate Field Team Actions)	Memo
22	Summer 2002	Bluestem	Yes	Investigative Search, **Aversive Conditioning** Habituated	Beaver Creek Ranch, Apache National Forest, Arizona. On several occasions the wolves were in the area of the Beaver Creek Ranch headquarters and cabins. No direct interaction between wolves and humans. Several dogs and horses at residence. Project personnel intensively monitored wolves, aversively conditioning wolves when located in area. Wolves eventually stayed away from ranch.
23	Summer 2002	Francisco	Yes	Investigative Search	Four Drag Cattle allotment, Apache National Forest Hunter encountered wolves while hunting a mountain lion in a remote area. Hunter was on horseback with a pack of hound dogs. The dogs got in a fight with the wolves; one of the dogs suffered extensive injuries. Hunter heard the fight and rode his horse towards the wolves. He fired one shot in the air. However, one wolf would not let go of the one hound. The other three were about 50 yards away when he approached. He fired two more shots and ultimately scared away the wolf when he was within 10 yards. Hunter reported only being in fear for the dogs and never felt threatened himself. The wolves had an kill nearby and may have had pups in the area.
24	10/19/02	F624, M584; Gapiwi	Yes	Investigative Approach	Chicken Coop Canyon, Gila Wilderness, New Mexico. Hunters observed two wolves near camp. Later wolves followed outfitter (on horseback) and her dogs. Hound ran at wolves, brief fight, hound came back and wolves left.

Event	Date	Wolves Involved	Dog presence (Provoked)	Classification (Bolded Items Indicate Field Team Actions)	Memo
25	10/21/02	F624, M584; Gapiwi	Yes	Investigative Approach	On 10/21/02, two wolves came by outfitter camp. Meat from three elk near the camp. Dogs were also in camp. Hunters run out to take pictures, wolves leave. Adult male and female had rendezvous site near by with one pup.
26	5/1/03	M648 (?); Sycamore		Investigative Approach, Aversive Conditioning	Near Little Turkey Creek, Gila Wilderness, New Mexico. Turkey hunter observes wolf on trail during middle of the day. Wolf moved towards him, a rock was thrown at wolf, wolf leaves area.
27	May 2003	Sycamore		Investigative Search, **Removed**	Seventy-Four Draw, Gila National Forest, New Mexico. Young woman on horseback encountered 2 wolves. One wolf was approximately 10 yards away, while the other wolf was further away and moving away from the young woman. Gun fired to scare wolf off. Wolf displayed limited fear of the person and the gunshot, but eventually moved away.
28	Spring 2003	Unknown; Cienega pack territory	Yes	Investigative Approach	Foote Creek trail area, Apache National Forest, Arizona. Mountain lion hunters had wolf follow them for approximately a mile. The hunters had several hound dogs with them. The wolf never approached the hunters or dogs. The wolf eventually left the area.
29	7/1/03-7/31/03	F613; Red Rock		Investigative Search, **Aversive Conditioning** Habituated, **Removed**	Occurred around Aragon and Cruzville, New Mexico. Wolf near residences at Cruzville. Hit with one rubber bullet. Moved to Aragon area. Sighted repeatedly near residences, no direct threats; F613 would leave area or hide when observed. Caught near residence east of Aragon after killing a turkey. Wolf caught and returned to captivity.

Event	Date	Wolves Involved	Dog presence (Provoked)	Classification (Bolded Items Indicate Field Team Actions)	Memo
30	Fall 2003	M729; Red Rock	Yes	Investigative Search	Sheep Basin, Gila National Forest, New Mexico. Hunters pulled into their camp at night and found M729 confronting their two dogs, which were tied to a tree. The hunters got out of their vehicle and yelled at the wolf. The wolf stared at the hunters and eventually fled from the area. No threat to human safety. Wolf was drawn into the area by the presence of dogs.

APPENDIX II—Issues for Which Assessments Were Requested and Answers Referenced to the Text Above.

Specifically, we were asked to address nine questions within the scope of the paper above. Each of these questions was analyzed in a scientific manner and we sought to highlight data and/or these questions within the scope of the paper above. However, we also highlight specific answers here and reference specific sections of the larger paper for brevity and ease of reading.

1. Have wolves successfully established home ranges within the designated wolf reintroduction area?

   Data suggest that numerous home ranges have been established and maintained within the designated reintroduction area. Overall, 18 packs established home ranges in 39 cumulative pack years (See Table 1). However, many of these packs had a small proportion of the home range outside of the current reintroduction boundary.

2. Have reintroduced wolves reproduced successfully in the wild?

   Reintroduced wolves have successfully produced pups in the wild. Most of the successful reproduction has been documented between 2002 and 2003. Overall, 16 packs produced wild-conceived and wild-born pups. However, the average litter size was far below that observed in other populations and the projections in the EIS. Thus, overall pup production was slightly below the numbers projected in the EIS (Figure 3).

3. Is wolf mortality substantially higher than projected in the EIS?

   Wolf mortality rates were below the level identified in the EIS. However, the removal rates were higher than mortality rates and were the dominating processes influencing the population (See Tables 4 and 5). Combining removal and mortality rates to form a failure rate (e.g., wolves that did not persist on the landscape) indicated that overall levels were much higher than that predicted within the EIS (See Tables 4 and 5, and Figure 3)

4. Is population growth substantially lower than projected in the EIS?

   The projected population and current population are very similar (Figure 3). However, releases are also higher than projected in the EIS (Figure 3), and thus the population is likely artificially high.

5. Are numbers and vulnerability of prey adequate to support wolves?

   This is at best a difficult question due to the poor ability to quantify the level of vulnerable prey within the overall prey populations. Similarly, differing measurements produce differing results. For instance, the small number of pups per litter suggest that prey may be limiting within the population (See the

Reproduction and Population Growth section of the Discussion). Other matrices indicate the level of available and vulnerable prey is adequate (e.g., number of wolves predicted by Ungulate Biomass Index, weight loss indexes, and the level of intraspecific strife). Overall, we feel that the latter issues tend to point more strongly to enough vulnerable prey present within the Blue Range Wolf Reintroduction Area (BRWRA), but we encourage the reader to fully evaluate this based on the Predation, and Reproduction and Population Growth sections of this document.

6. Is the livestock depredation control program adequate? *(*include evaluation of the number of depredations vs. number projected vs. other wolf programs vs. the first 3 years of reintroduction).

   Each of the five measures we used to define a successful depredation control program indicated that the current methods were adequate. The number of confirmed wolf-killed cattle was within the projections made in the EIS, although slightly higher than that observed in other populations of gray wolves. This higher relative number of killed cattle within the BRWRA relative to other wolf populations likely relate to differing grazing schemes between the areas (i.e., year-round grazing).

7. Have documented cases of threats to human safety occurred?

   No cases of any physical contact between a wolf and a human have occurred during the six years of data analyzed. On three occasions wolves behaved aggressively towards humans or the dogs that accompanied the humans (see Appendix I). In all of these cases wolves were within three months of initial release, and dogs were present with the owners.

8. Have any sinks been identified?

   Sinks were scattered both inside and outside of the BRWRA (see Figure 5). Two clusters of sinks occurred within the BRWRA one in the northwestern corner of the reintroduction area and one in the northeastern corner of the reintroduction area.

9. Have any sources of mortality been significantly higher than expected?

   Sources of mortalities are consistent with other studied populations and were principally related to human causes (e.g., illegal shootings, or vehicle collisions).

APPENDIX II—Responses to Suggested Changes Identified in the Three-Year Review Process.

Mexican Wolf Project
Interagency Field Team Five Year Evaluation
Three-Year Recommendation Implementation Plan Status

Recommendations from the Conservation Breeding Specialists Group:

1. **Continue to develop appropriate opportunities to release (and re-release) wolves for at least 2 years to ensure the restoration of a self-sustaining population**

   Status (Time Frame): Completed/being implemented (ongoing)

   Justification: Releases and translocations continue to be used as management actions to ensure the restoration of a self-sustaining wolf population. Adaptive management will facilitate the continuation of these management practices as needed in the future.

2. **Begin developing population estimation techniques that are not based exclusively on telemetric monitoring.**

   Status (Time Frame): Not completed/being implemented (initial stages; time frame for completion unknown)

   Justification: Staff and funding have not been available to fully implement this recommendation. Currently the Interagency Field Team (IFT) uses howling surveys, track counts, and observational data, in association with trapping/collaring, and telemetric monitoring, to obtain population estimates. A standardized system for determining population estimates still needs to be developed, and additional techniques need to be implemented or refined. However, most scientists believe that the current methodology is the most appropriate for a small intensively monitored population.

3. **Develop data collection forms and data collection and management procedures similar to those used by the red wolf restoration program in North Carolina.**

   Status (Time Frame): Completed/being implemented (ongoing)

   Justification: New forms and procedures have been incorporated into numerous Standard Operating Protocols (SOP) and other procedural documents, using examples from projects in Minnesota, North Carolina, and the Northern Rockies.

4. **Require biologists to promptly and carefully enter field data into a computer program for storage, proofing, and analysis.**

Status (Time Frame): Completed/being implemented (ongoing)

Justification: The IFT has developed, enhanced, or maintained project databases for all essential field data including, but not limited to, wolf locations, mortalities, survivorship, incident reports, depredation investigations, releases, and predation/carcass analysis. In addition, a comprehensive database documenting the chronological history for all wolves past and present, both in the wild and in acclimation facilities, has been created, and is regularly maintained for accuracy and completeness.

5. Make all data available for research and peer review.

Status (Time Frame): Completed/being implemented (initial stages; time frame for completion unknown)

Justification: The accessibility of project data for research and peer review is available to individuals and entities with appropriate research proposals. Data have been made available to a graduate-level scat study, the Three-year Review, depredation study, undergraduate summer intern study, and an upcoming graduate-level study on Mexican wolf predation patterns. The Five-year Review will provide additional information for peer review.

6. Carefully consider using a modified #3 soft-catch trap for capturing Mexican wolves rather than the McBride #7

Status (Time Frame): Completed

Justification: The IFT considered using the modified #3 traps and decided not to use them because the amount of injuries documented using McBride #7 traps was minimal, and the concern that too many wolves would be able to pullout of the #3 soft-catch traps. The Mexican wolf program has documented wolves pulling out of the McBride #7 and the New House # 4 traps; using the modified #3 traps would likely increase the occurrence of "pull-outs. "

7. Encourage research that will help inform future program evaluations and adjustments.

Status (Time Frame): Completed/being implemented (initial stages; ongoing)

Justification: Currently, the project is implementing a cattle depredation study and a preliminary winter predation study within the Blue Range Mexican Wolf Recovery Area (BRWRA). In addition, a graduate-level study on wolf predation patterns has been implemented in the fall of 2004.

8. **Develop a contemporary definition of a biologically successful wolf reintroduction and the criteria needed to measure success.**

   Status (Time Frame): Not completed/being implemented (one-two years?)

   Justification: The criteria to measure reintroduction and recovery success will be updated in the new Southwestern Distinct Population Segment of the Gray Wolf Recovery Plan (Recovery Plan), now being written. After recovery goals have been established for the entire Southwestern Distinct Population Segment, the BRWRA can be evaluated relative to those goals.

9. **Initiate programs to educate people about wolf behavior.**

   Status (Time Frame): Completed/being implemented (ongoing)

   Justification: Educating the public about wolf behavior is vital for a successful program and was implemented even before wolves were released. Wolf behavior, dealing with nuisance wolves and depredations, status of the wolf project, and other topics are regularly discussed at presentations. In addition, project staff are knowledgeable and able to answer many other types of questions about the project.

10. **When writing or lecturing about the project, the Service should emphasize a community approach to understanding the wolf reintroduction project and its effect on other species and ecological processes.**

    Status (Time Frame): Completed/ being implemented (ongoing)

    Justification: The effects of wolves on other ecological process need to be, and have been, presented to provide a comprehensive description of wolf recovery. Negative impacts of the program on local residents and livestock have also been included in presentations.

Recommendations from the Stakeholders Workshop:

11. **Create maps and reports that reflect population levels of prey base, their spatial and temporal distribution, and current and projected management objectives and direction for New Mexico, Arizona, and Mexico.**

    Status (Time Frame): Not completed/being implemented (time frame for completion unknown)

Justification: Detailed information on spatial, temporal, and density distribution of prey species would be helpful, but funding and personnel restraints in all three Game and Fish agencies (Arizona, New Mexico, White Mountain Apache) preclude such detailed surveys. Current management objectives for ungulates within the BRWRA can be obtained from the appropriate management agency [Arizona Game and Fish Department (AGFD), New Mexico Department of Game and Fish (NMDGF), or White Mountain Apache Outdoor and Recreation Department (WMAORD)]. Projected game management objectives cannot be described at this time because of the many variables that affect future management strategies. In Mexico, wildlife management is much more complex and less structured, due to the large amount of private land, and financial ability of numerous government agencies, to carry out these activities.

12. **Identify wild ungulate prey base habitat enhancements to be accomplished through private property incentives programs and federal, state, tribal, and county, land management agency planning processes.**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: This recommendation is being implemented through Habitat Partnership Committees, Stewardship Programs, and agency management plans. This recommendation could benefit the low-density deer herds, and could reduce conflict between elk and livestock.

13. **Predation losses to be determined by cooperators and stakeholders on game species and develop definitive statements on anticipated allocations of wild ungulates to wolves and hunters.**

    Status (Time Frame): Not completed/being implemented (partially implemented; time frame for completion unknown)

    Justification: Intensive winter monitoring has provided minimum food consumption rates and characteristics of prey being fed on by wolves. Supporting information is gathered through the analysis of other wolf kills found opportunistically throughout the year. An upcoming graduate-level study on Mexican wolf predation patterns should provide further insight towards food habits of wolves. However, losses to predation will be localized and difficult to determine without additional research focused on the population dynamics of ungulates. Allocating wild ungulates to predators and humans is not currently, or planned as, a management strategy in Arizona, New Mexico, or on the Forte Apache Indian Reservation (FAIR).

14. **When livestock depredation is suspected utilize partnerships between stakeholders to assist with increased monitoring of vulnerable livestock and local populations of wolves in order to determine if and when depredation occurs.**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: When wolves are in close proximity to livestock, project personnel inform ranchers and other livestock owners, of wolf locations. In addition, when wolf territories overlap with active livestock pastures, and depredations are confirmed or suspected, livestock managers may be provided telemetry equipment to assist with monitoring of vulnerable livestock. Under these circumstances, the IFT intensifies monitoring efforts, and additional assistance (i.e., riders, ranch-hands, monetary compensation etc.) can be acquired through Defenders of Wildlife, a non-government organization (NGO).

15. **Notify livestock operators when wolves are likely to den in livestock pastures and consider modifying livestock grazing use to minimize opportunities for depredation.**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: This recommendation has been implemented with successful results through partnerships between the IFT, livestock permittees, U.S. Forest Service, and the Defenders of Wildlife.

16. **Inform livestock operators of procedures to preserve evidence of depredation and contact points to have kills confirmed.**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: This information is provided to livestock operators that have wolf/livestock conflicts through personal communication. In addition, an informational flyer has been developed with this information and currently is being distributed.

17. **When wolves are confirmed to be involved in livestock depredation, apply direct control measures in an attempt to curtail depredation and monitor effects to determine if depredation reoccurs**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: Direct control measures and circumstances for their use are described in SOP #13 (Control of Mexican Wolves). Intensive monitoring and direct control measures are implemented after depredations are confirmed or suspected, in accordance with protocols.

18. **If wolves are observed chasing/harassing livestock, utilize aggressive aversive conditioning in an effort to curtail the behavior and if these attempts fail take direct control actions to curtail the behavior or remove the offending animal or animals.**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: Aggressive aversive conditioning may be successful in temporarily deterring wolves from livestock in some cases. Direct control measures may be needed but other less drastic options need to be implemented before direct control (removal) of the wolves will occur. These management responses are conducted in accordance with SOP #13 (Control of Mexican Wolves).

19. **Review and refine the criteria for release site selection and timing, including: potential conflicts with previously released wolves, potential conflicts with land uses; potential conflicts with humans; potential conflicts with management priorities for other species of wildlife; desired impacts on other species (i.e., reducing populations of other predators), den-site potential; wild ungulate prey base abundance and availability; post-release movements and dispersal potential; any other relevant biological factors; logistical feasibility; cost of field monitoring; and field project staffing needs**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: A comprehensive analysis of release site areas should increase chances of wolf survival and reproduction, and lessen impacts to current land uses, and local residents. Through adaptive management and information gained from previous releases, the release site selection process has become more refined and likely to have increased success in the future. In addition, SOP #5 and #6 (Initial Releases and Translocations of Mexican Wolves, respectively) is currently being developed to standardize these management actions.

20. **Create a review team that includes stakeholders to identify and prioritize potential release sites within the reintroduction area (includes timing, prey base, land ownership).**

    Status (Time Frame): Not completed/being implemented (initial stages; time frame for completion unknown)

Justification: This task was conducted for the spring, 2004, release proposal, by the Adaptive Management Oversight Committee (AMOC) and the Adaptive Management Working Group (AMWG), with stakeholders represented on each, and a special meeting with local residents. This recommendation was considered not completed because a new review team was not created to accomplish this task. In Arizona, this was done initially to identify the eight original release sites within the primary recovery area, and also on the Fort Apache Indian Reservation through the White Mountain Apache Tribal planning process. Similarly, New Mexico completed this task for four initial sites selected within the Gila wilderness.

21. **Develop criteria for class of wolves to be released (individual vs. pack; male vs. female; pregnant female; old vs. young; etc.).**

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Analysis of previously released wolves to determine the most successful characteristics has helped in making future releases more successful. For example, a pair released with pups shows high site fidelity, with minimal dispersal, and a greater likelihood of contributing to population growth. However, adherence to strict criteria may not be possible given the relatively small number of genetically surplus wolves that can be released, and other field considerations.

22. Develop a formal supplemental feeding protocol.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Supplemental feeding is dictated by factors such as: 1) utilization of food caches 2) wild experience of released wolves 3) release site fidelity 4) natural prey utilization, etc. Flexibility must be maintained to allow for adaptive management under dynamic situations. Therefore, the IFT has developed a flexible supplemental feeding protocol, SOP # 8 (Supplemental Feeding and Monitoring).

23. Review and refine all depredation management procedures and guidelines on public and on private lands.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Depredation management procedures and guidelines were reviewed and refined during the development of SOP #13, (Control of Mexican Wolves), SOP #11 (Wolf Depredations of Domestic Livestock and Pets), and SOP #10 (Incident Reporting).

24. **Review and refine all procedures and guidelines for detecting and monitoring released wolves, radio-tracking and recapture practices in proximity to livestock and elsewhere.**

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Procedures and guidelines for detecting, monitoring, and capturing wolves were reviewed and refined during the development of SOP #21 (Immobilization and Processing of Mexican Wolves), SOP #15 (Helicopter Capture of Mexican Wolves), SOP #22 (Chemical Darting of Mexican Wolves), SOP #23 (Blood Collection, Handling and Storage), SOP #18 (Aerial Telemetry), SOP #17 (Ground Telemetry), SOP #16 (Howling Surveys), SOP #11 (Wolf Depredations of Domestic Livestock and Pets), and SOP #13 (Control of Mexican Wolves), all of which are finished or are in review.

25. **Review and refine all procedures and guidelines for translocation.**

Status (Time Frame): Completed/being implemented.

Justification: Translocation procedures and guidelines were reviewed and refined during the development of SOP #5 and SOP#6 (Initial Releases and Translocations of Mexican Wolves, respectively), currently being finalized.

26. **Review and refine all criteria, procedures, and guidelines for temporary and/or permanent removal from the wild of released wolves.**

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Criteria, procedures, and guidelines for removal of wolves were reviewed and refined during the development of SOP #11 (Wolf Depredations of Domestic Livestock and Pets) and SOP #13 (Control of Mexican Wolves). The current procedural documents do not distinguish between permanent and temporary removal. Relocating wolves previously removed from the wild is recommended by the IFT, and approved by the respective agency where the release site is located. Relocating wolves is based on cause of removal, genetic profile of population, population density, and amount of breeding pairs in the wild.

27. **Review and refine all procedures and guidelines for preventing, managing, or monitoring dispersal.**

Status (Time Frame): Not completed/being implemented (time frame for completion unknown)

Justification: Analysis of previously released wolves to determine the age class of most common dispersers, pack size with highest dispersal rates, and other circumstances of dispersal has allowed the IFT to better prevent, manage, and monitor dispersal. Routine aerial and ground telemetry monitoring has allowed the IFT to track dispersing wolves. Formal procedures or guidelines have not been developed specifically for dispersal, but portions of this recommendation are covered in various other project documents such as: the Environmental Impact Statement, the nonessential experimental rule, and various SOPs [i.e., SOP #5 and #6 (Initial Releases and Translocations of Wolves, respectively) and SOP #13 (Control of Mexican wolves)]. However, it needs to be recognized that dispersal is a natural behavior of wolves, which facilitates natural pair formation, reproduction, and recolinization. Therefore, it is impossible to prevent and is extremely time consuming to manage dispersal behavior.

28. Review and refine all procedures and guidelines for detecting or monitoring prey use.

Status (Time Frame): Not completed/being implemented (time frame for completion unknown)

Justification: Various activities of the IFT are designed to document prey use (i.e., winter study, depredation study, and planned graduate research). In addition, wolves are intensively monitored after direct releases from captivity or when in close proximity to cattle, to determine prey utilization. SOP #19 (Intensive Winter Monitoring and Ungulate Mortality Collection) outlines specific guidelines for detecting and monitoring prey use, through intensive aerial and ground monitoring, currently being reviewed.

29. Review and refine all procedures and guidelines for detecting and monitoring selection and use of den sites.

Status (Time Frame): Not completed/being implemented (time frame for completion unknown)

Justification: Routine monitoring has detected the selection and use of most den sites; therefore, formal procedures or guidelines have not been deemed necessary by the IFT. Some den sites have been analyzed for their physical and biological characteristics.

30. Review and refine all procedures and guidelines for detecting and monitoring reproduction.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Presently there is no procedural document for detecting and monitoring reproduction. The IFT initially documents reproduction through monitoring, observational data, localized movements during denning season, and later determines successful reproduction through den site analysis, howling for pups, and observations. The current field practices of the IFT have been very successful at determining reproduction.

31. **Review and refine all procedures and guidelines for detecting and monitoring pup recruitment (survival past 1 year).**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: The IFT currently documents recruitment through collaring pups and tracking survival. Supplemental information is obtained by acquiring pack size and pup counts through observational reports, howling surveys, and track counts. Collaring or ear tagging pups with remote transmitters is the best way to accurately determine pup recruitment (survival past one year).

32. **Review and refine all procedures and guidelines for detecting and monitoring availability and use of water.**

    Status (Time Frame): Not considered necessary to complete/implement

    Justification: Implementing this recommendation would require intensive monitoring and research efforts beyond the current scope of the IFT. Prior to releasing wolves the IFT considers the proximity of a release site to perennial water sources, as part of the projects release site criteria. Creating procedures and guidelines for detecting and monitoring water availability and use has no other application for the Mexican Wolf Reintroduction Project, and therefore, is deemed unnecessary by the IFT.

33. **Review and refine all procedures and guidelines for identifying and addressing conflicts with land uses and land users.**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: Conflicts with land uses and users are identified and addressed through AMOC and AMWG.

34. **Develop procedures and guidelines for minimizing undesired and maximizing desired impacts on other species of wildlife.**

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Concerns over minimizing undesired and maximizing desired impacts of the wolves are addressed through AMOC and AMWG. Provisions to address this topic are incorporated into the EIS, nonessential experimental population rule, and SOP #13 (Control of Mexican Wolves). Additional procedures and guidelines will be developed when issues arise.

35. Review the protocol for husbandry of captive pre-release wolves in on-site acclimation pens to ensure it is adequate to maximize post-release survival and breeding success.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: A husbandry protocol for the captive wolves in on-site acclimation pens was developed in 1998 prior to the first release of Mexican wolves. Since the inaugural release of Mexican wolves in 1998, project personnel have been refining the methodology used for releases. By altering the techniques used to release wolves from captivity through adaptive management, the program has increased survivorship.

36. Develop guidelines to ensure that project staff solicit and consider information from all available knowledge bases (including published and unpublished sources, locally knowledgeable individuals, natural historians, academicians, agency staff, and historical as well as recent information) during project planning and implementation.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: During the development of SOPs and other procedural documents, IFT members solicit and consider information from professionals and specialists within the field of wolf research/management, review published and unpublished documents, and research archived data within each of the respective agencies. AMOC and AMWG provide opportunities to use all available knowledge bases in other planning and implementation stages including public/stakeholder input.

37. Compile data to ensure availability of data

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Data is collected and compiled on all facets of the reintroduction project, including but not limited to: wolf locations, mortalities, incident reports, observation reports, depredation investigations, predation/carcass analysis, releases/translocations, acclimation facilities, and the captive breeding program. Project personnel assimilate archived data to disseminate internally amongst the cooperating agencies, the public, and academic entities. Information dissemination occurs through project status reports, monthly updates, commission briefings, recommendations, proposals, and numerous technical, professional and general presentations. In addition, data was made available for the project's Three-year Review and is gradually being granted to academia for research purposes.

38. Develop the Five-year Review criteria

Status (Time Frame): Completed/being implemented

Justification: Criteria have been proposed and approved by the AMOC.

39. Develop the Five-year Review process

Status (Time Frame): Completed/being implemented

Justification: The Five-year Review process has been approved by the AMOC.

40. Provide technical training opportunities for field staff in the broader recovery zone and other wolf projects (including Mexico) in order to standardize methods and provide quality control.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Several Mexican wolf project employees have participated in the red wolf recovery program, the northern Rockies wolf recovery project, and the northeastern wolf recovery project prior to working with the Mexican wolf program. Frequent discussions with other projects and familiarity with the literature has helped ensure standardized methods and quality control. Continuing education for staff will help staff retention and make the project more effective and efficient. Mexican interns have worked on the Mexican wolf reintroduction program, acquiring technical skills and exposure to policies and procedures, and developing a partnership with their U.S. counterpart.

41. Ensure that project staff have competency in data gathering, storage, retrieval, and analysis.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Some staff are trained and evaluated in data gathering, storage, retrieval, and analysis. On the job training and fulfillment of employee professional development plans provides project personnel with opportunities to enhance and refine their ability to accomplish the aforementioned objectives. However, agencies need to provide their staff with more opportunities to acquire skills and appropriate knowledge required to perform these tasks using current scientific methodologies. Agencies should identify deficiencies through regular job performance appraisals.

42. Ensure that project staff have competency in verbal and written communication skills

Status (Time Frame): Completed/being implemented (ongoing)

Justification: All appropriate staff are trained and evaluated in verbal and written communication skills.

43. Agency personnel should attend at least two communication training sessions annually.

Status (Time Frame): Not considered necessary to complete/implement

Justification: Project personnel attend regular training as part of their respective professional development plans, and are also continually involved with on the job training opportunities. However, training opportunities don't necessarily involve communication enhancement exercises, nor has it been deemed necessary for staff to attend two communication-training sessions annually.

44. Develop mechanisms to communicate and inform stakeholders, especially for local communities

Status (Time Frame): Completed/being implemented (ongoing)

Justification: AMOC and AMWG provide opportunities for local communities and other stakeholders to communicate directly with project managers quarterly, within or near the BRWRA. In addition, monthly updates are posted on project websites and disseminated throughout local communities within the BRWRA. Furthermore, livestock producers and affected members of the public are informed about wolf presence, depredations, and nuisance animals found in the vicinity of their livestock or residence.

45. Provide accurate bi-monthly information on FWS website by the USFWS

Status (Time Frame): Completed/being implemented (ongoing)

Justification: In 2003, the IFT converted bi-monthly updates into monthly updates to increase the amount of detail and depth of these informational reports. These reports are also accessible via the USFWS and AGFD websites. Individuals requiring immediate information on wolf locations (i.e., livestock producers and affected citizens), due to depredations or nuisance behavior, are provided with information expeditiously by the IFT.

46. Identify resources, individuals, or groups that can aid outreach activities.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: This recommendation was completed through the development and coordination of teacher's wolf workshops, in cooperation with the Information and Education Branch of the Arizona Game and Fish Department, and other organizations. Partnerships between the IFT and volunteer groups are also occurring to aid in the development and dissemination of outreach material; however, this form of outsourcing is only in its initial stages.

47. Information provided in outreach programs should be balanced and objective and not designed to persuade attitudes and opinions.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: All information provided during outreach programs is evaluated for its balance and objectivity as outlined in SOP #3 (Outreach Response). Recommended changes can be made through IFT staff and supervisors, public comments, AMOC, and AMWG.

48. Increase the sensitivity of program staff and partners to cultural differences in attitudes and values specific to the program.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Project personnel are cognizant that there are a diverse array of cultural attitudes and values specific to the program. Information is presented to the public in a non-biased manner and project personnel are receptive to all questions and concerns. Understanding different cultural attitudes and values towards the program enables program administrators to appropriately represent the full spectrum of public constituents. AMOC and AMWG provide forums for the public and public representatives to address issues of this nature.

49. Scientists and administrators involved in the program need to have a high level of sensitivity to the political factors, operating at various levels, that seek to influence the program and resist purely politically motivated solutions to problems.

Status (Time Frame): Completed/being implemented

Justification: The IFT generally attempts to resolve issues by specifically addressing solutions based upon the scientific literature and overall working knowledge of specific problems. Ideally, administrators will continue to support these scientifically sound approaches to resolving conflicts.

50. Incorporate local citizen views into the Mexican gray wolf recovery program.

Status (Time Frame): Completed/being implemented

Justification: AMOC and AMWG provide opportunities for local citizen's views to be incorporated into the recovery program. In addition, the Southwestern Distinct Population Segment of the Gray Wolf Recovery Team (Recovery Team) stakeholder group is composed of representatives from local communities and organizations involved in the development of the new Mexican Wolf Recovery Plan.

51. Cooperators and stakeholders develop and define measurable techniques for reducing livestock and animal conflict by the end of the Five-year Review.

Status (Time Frame): Not completed/being implemented (time frame for completion unknown)

Justification: Techniques to reduce livestock and animal conflicts are described in the SOP #13 (Control of Mexican Wolves). DOW coordinated discussions with project cooperators, stakeholders, and interested parties, trying to develop an insurance compensation program for livestock depredations, which doesn't require depredations to be confirmed in order to receive monetary compensation. However, this compensation system is only a concept being proposed, currently in preliminary discussion phase. Project personnel also acquire input from stakeholders through day-to-day interactions.

52. Develop information dissemination network to provide current and timely information to pet owners, sporting dog owners, recreationists within occupied wolf areas.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Project briefings and signs are posted throughout the recovery area, special notices are posted at trailheads or campgrounds, and personal contacts are made with campers, hunters, and residents when wolves are in their area.

53. Minimize management action (e.g., capture/recapture, supplemental feeding, removal of wolves).

Status (Time Frame): Completed/being implemented

Justification: Management actions have been minimized through application of hazing techniques, release of family groups with pups, reductions in the number of wolves directly released from captivity, and less supplemental feeding of wolves. However, management actions will always be needed to address various reintroduction concerns.

54. Monitor long-term disease and health trends to include a health assessment and vaccinations into wolf handling protocols to limit health and disease concerns.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Long-term disease and health trends have been and are currently being monitored through regular testing of wolves and blood samples. Health assessments, vaccination tracking, and blood collection have been incorporated into SOP #21 (Immobilization and Processing of a Live Mexican Wolf).

55. Identify local misconceptions, with help of local sources of the Mexican wolf, and address them as part of the outreach plan.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Many local misconceptions were identified through the Three-year Review public open house and workshop process. All attempts were made to address these misconceptions in the development of SOP #3 (Outreach Response), and are carried out by project personnel during formal presentations, and informal communication with the public.

56. There is a need to address the issue of livestock carcass detection and disposal to reduce wolf and livestock conflicts.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Livestock carcasses, which are not killed by wolves, are made unavailable to wolves either through removal or on-site disposal by the IFT when feasible. Carcasses that are seen on aerial telemetry flights, or discovered through regular field monitoring, are routinely disposed of on public lands. Similar actions are taken by the IFT on private lands when given permission.

57. Compile and review all monitoring and recapture information collected to date on dispersing wolves to evaluate effectiveness, program costs, and impacts to landowners and other stakeholders due to current boundaries.

Status (Time Frame): Not completed (time frame for completion unknown)

Justification: It will be difficult if not impossible to split off time and expense figures to monitor dispersing wolves. In addition, the effectiveness of the activities would be difficult to define and the impacts to landowners may be extremely difficult to quantify. However, managing wolves that establish territories wholly outside of the BRWRA requires an extensive amount of resources, and limits the ability of IFT staff to purse other field operation responsibilities.

58. Conduct a staffing need assessment based on project experience to date.

Status (Time Frame): Completed/being implemented (2005)

Justification: Arizona Game and Fish Department has conducted a staffing needs assessment, and has initiated an expansion and reorganization of the AGFD portion of the IFT to reflect roles and responsibilities, as described in the recently approved Memorandum of Understanding. Thus, during 2005 AGFD will likely have 5 full time staff dedicated to the Mexican wolf program. The White Mountain Apache Tribe recruited a technician in 2003, to complement the current Wolf Biologist position. The USFWS stationed the Mexican Wolf Field Coordinator in Alpine, AZ, to facilitate communication between cooperating agencies and become a functional member of the IFT. New Mexico Department of Game and Fish (NMDGF) is currently evaluating the potential for additional personnel on the IFT. However, at this time no changes have occurred within the staffing of the NMDGF.

59. Compile, review, and publish an assessment of all release program impacts reported to date on existing land uses, local customs, cultures, and economies in Arizona and New Mexico, including a determination of appropriate measures.

Status (Time Frame): Not completed/being implemented (February, 2005; completion of Five-year Review)

Justification: This recommendation will be partially addressed in the socioeconomic portion of the Five-year Review.

60. Compile and analyze all incidents involving livestock, other domestic animals, or humans to identify preventative measures and to assess the effectiveness of current management options.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: All reported incidents of wolf-livestock or wolf-human interactions during the initial stages of the project are described in the biological portion of the Three-year Review. Investigations of depredation sites are all recorded on standard investigation forms for further analysis. A livestock depredation study was initiated in 2002, to help address these issues.

61. Assess the impact of wolves on other species of wildlife.

Status (Time Frame): Not completed (time frame for completion unknown)

Justification: To produce valid information a study would have to extend over several years, for each species studied, requiring significant funding which has not been available. With approximately 50 wolves spread out over 2,500 mi^2 it would be very difficult to assess with any accuracy the wolves' impact on other species of wildlife, in any specific area. Another impediment to completing this recommendation is the lack of any defensible density data for the various prey populations in the area. However, it appears that computer models included in the EIS are fairly accurate in their predictions.

62. Survey the public, academicians, and agencies to identify areas in which they believe they can appreciably contribute knowledge that is not currently reflected in the program.

Status (Time Frame): Completed/being implemented (ongoing)

Justification: This was done through the Three-year Review process, and continues through the activities of AMOC and AMWG, as well as, the Five-year Review. The Recovery Team is comprised of a diverse group of people from the public, academics, and government agencies; this entity contributes knowledge and information not reflected in the program.

63. **Survey the public and program staff to identify information gaps, weaknesses, perceived misleading information that affect their understanding of the need for and/or quality of the program.**

Status (Time Frame): Completed/being implemented (ongoing)

Justification: This is already being done on an informal basis but could become more structured to provide more complete information to the public. This was done through the Three-year Review process and continues through the activities of AMOC and AMWG, as well as, the Five-year Review.

64. **Collect data on aversive conditioning to identify management actions.**

Status (Time Frame): Completed/being implemented

Justification: Aversive conditioning, under most circumstances, has not proven to be an effective long-term solution to problem wolves on this project, but hazing of wolves through intensive short-term harassment usually causes wolves to move from an area temporarily or sometimes permanently. Management actions conducted by the project revealed that aversive conditioning has greater success in smaller refined areas.

65. **Collect data on Mexican wolf food habits to quantify actual diet composition.**

Status (Time Frame): Completed/being implemented (ongoing)

Justification: Graduate student, Janet Reed, has completed her Masters project analyzing wolf scats to determine food habits of Mexican gray wolves. Intensive winter monitoring and opportunistic collection and analysis of wolf kills have also provided characteristics of prey used by Mexican gray wolves. In addition, a graduate level study on wolf predation patterns is scheduled to begin in 2004.

66. **Conduct a population/habitat viability analysis of the wild population in the BRWRA using modern, scientifically accepted methods, to be completed by FWS contracted experts by February 2002.**

Status (Time Frame): Not completed/being implemented (2005)

Justification: This recommendation will be implemented as part of the Southwestern Distinct Population Segment of the Gray Wolf Recovery Plan.

67. **Establish baseline numbers and distribution data for selected (examples) wild organisms and ecological processes by August 2002, and implement ongoing monitoring of change.**

    Status (Time Frame): Not completed/being implemented (time frame for completion unknown)

    Justification: General measures of prey abundance and classification are currently being collected by state Game and Fish agencies, but a more complete analysis of ecological process will require research assistance through a University, since this level of analysis is beyond the funding scope of the reintroduction project.

68. **Analyze the short and long term effects of management actions on wolf behavior, social structure, and evolution.**

    Status (Time Frame): Not completed/being implemented (time frame for completion unknown)

    Justification: Analysis of management actions is an ongoing activity.

69. **Collect and analyze all available historical information on past wolf numbers and distribution.**

    Status (Time Frame): Completed

    Justification: This information can be found in the EIS for the reintroduction of Mexican wolves.

70. **Develop a better understanding of ethical considerations related to Mexican gray wolf recovery, including the reintroduction of captive-raised predators into the wild, allowing extinction of this sub-species, and the conflicting attitudes and resulting stresses among residents of the area directly affected by wolf recovery.**

    Status (Time Frame): Completed/being implemented (ongoing)

    Justification: Extensive deliberation occurred on whether or not Mexican wolves should be reintroduced prior to the inception of the reintroduction effort, analyzing the ethical, biological, and socio-political implications and ramifications. Conclusions from this analysis were incorporated into the governing policies, rules, and regulations that govern the reintroduction project. Ethical considerations are now discussed and analyzed through AMOC and AMWG.

71. Contract an independent comprehensive economic (cost - benefits) analysis that evaluates and quantifies the potential and actual benefits and losses of the Wolf Reintroduction in the activities of the local communities. The results have to be immediately incorporated to the adaptive management in the program, the Five-year Review and any subsequent reviews in order to maximize the benefits and minimize the costs.

Status (Time Frame): In progress. Completion by the end of the Five-year Review process.

Justification: A socioeconomic study is being implemented through this Five-year Review process.

72. Evaluate effectiveness of current compensation fund and implement monetary reimbursement.

Status (Time Frame): Not completed/being implemented (time frame for completion unknown)

Justification: A sub-group from AMOC has been created to handle this issue. This recommendation may be implemented through the Five-year Review.

73. Analyze behavior of wolves released to date to determine what the recovery zone boundaries should be from a biological perspective (i.e., considering denning and foraging behavior, and seasonal or other movements).

Status (Time Frame): Not completed (Less than a year to be completed)

Justification: Preliminary analyses by the IFT reveals that present recovery zone boundaries are inadequate and impeding wolf recovery. Wolves are natural disperses, traveling extensive distances in search of available territory, mates, and appropriate habitat. Since the inception of the project, several wolves have dispersed outside of the BRWRA, and even the experimental recovery area, before localizing and establishing a territory. A few denning packs have also established territories wholly outside of the BRWRA. All of the aforementioned wolves were subsequently removed and relocated due to this violation of the boundary rule. Further analysis is being conducted through the Five-year Review and during the development of the new Recovery Plan, to determine whether or not recovery zone boundaries should exist, and if so what they should be from a biological perspective. The analysis of this recommendation has also been directed as an agenda item to the NMDGF by their wildlife commission.